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CONTRIBUTIONS:

All Letters and Contributions intended for Publication should be addressed to:—
K. R. DOGGETT, Editor,
"The Dock and Harbour Authority,"
19, Harcourt Street, London, W.1.
Telephone: PADdington 0077/8.

The Dock & Harbour Authority

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Editorial Comments

The Loire Ports.

In this issue will be found translated from the French an informative article by M. Gibert on the River Loire and the ports at its mouth—more particularly Nantes, with its outport St. Nazaire. Both these suffered in a major degree from the destructive activities of the German forces during the period of evacuation, as also from the unfortunately necessary attentions of the British Commandos in their heroic raids on the ports' installations during the occupation period.

The Loire is the longest river in France and its channel extends to a length of 625 miles, cutting through the productive central area of the country and affording seaward communication with the Atlantic to numerous cities and towns on its banks. The historic city of Nantes is its chief port, as it is also the capital of Brittany, with a pre-war population of over 200,000.

The maritime installations of Nantes and its daughter port, St. Nazaire, are of a very interesting character and will repay the attentive consideration of our readers. Moreover, the vagaries of the Loire, with its sandbanks and shifting channels, exhibit a problem of special interest to river engineers.

The reinstatement of the ports of the Loire is proceeding apace and, no doubt, very shortly they will have resumed the important position which they attained in recent times.

The association in close proximity of the two ports of Nantes and St. Nazaire finds a parallel in the similar conjunction of London and Tilbury, of Hamburg and Cuxhaven, and of Bremen and Bremerhaven. In all these cases, the creation of an outport at the mouth of the river on which the inland port is located has served to relieve congestion and has been influenced, in most, by the need in the first instance of enabling deep draughted vessels to discharge a part of their cargo before attempting the difficulties of navigating a river channel of restricted depth.

Permanent Dock Labour Scheme.

The draft of a permanent scheme for the decasualisation of dock labour at British ports, to come into operation on July 1st, is a document of no little importance. An outline of its provisions is given in this issue.

Hitherto there have been in force temporary schemes devised by the Ministry of Labour, under the National Dock Labour Corporation, relating to various ports with special treatment under the Ministry of Transport for the Merseyside and Clydeside ports. Under the new scheme, these latter will be included in the general arrangement with the other ports specified.

A period of 40 days, dating from March 3rd, has been allowed for objections to the scheme to be lodged, and on March 21st, at a special meeting of two hundred delegates from ports in Great Britain, representing the five dockers' Unions, was held to consider the matter. At this meeting it was decided to submit a series of amendments, dealing principally with disciplinary provisions, unregistered men, and administrative details. It will, therefore, not be possible to treat the scheme in its final form until these various points have been settled.

The issue of the draft scheme, which is entitled the "Dock Workers (Regulation of Employment) Scheme, 1947," marks the concluding stage of the movement which has been in progress for over a quarter of a century, dating back to, and even preceding, the Shaw Report of 1920, for the systematic regulation of dock labour and the elimination of its casual character, which has been its bane and the cause of much unrest and disaffection. It is to be hoped that finality will at length be achieved, though some "teething troubles" will, no doubt, manifest themselves before the period of smooth working is reached.

British Ports and the Transport Bill.

The Dock and Harbour Authorities' Association, the Canal Association and Joint Committee, and the Chamber of Shipping of the United Kingdom, were co-signatories with other transport and industry organisations of a statement issued during the past month by an influential Liaison Committee, presided over by Sir Charles Newton, Chief General Manager of the London and North Eastern Railway, calling on the Government to suspend procedure with the Transport Bill on the ground that the time is not opportune for attempting to alter the whole structure of the transport system of the country and, in particular, to introduce radical changes in the administration of ports and harbours. The statement asserts that "time and energy which could and ought to be put to more pressing problems are being diverted to the consideration of a highly controversial measure."

With the political aspect of nationalisation, the Journal has no concern, nor have we any intention of advocating or opposing measures which may be promulgated by either political party as such, in the alleged national interest, but, as regards the economic effect of such measures it is our duty and responsibility to utter a warning, as in this particular case we have already done, on the adverse consequences likely to follow any interference with the present system of port management on the lines envisaged in the terms of the Bill.

We would go further than the very moderate demand for a temporary suspension of parliamentary procedure made in the statement and urge the entire abandonment of a policy which, far from benefiting the trade and commerce of the country, can only result in a dislocation of business and a general state of upheaval and confusion at British seaports at a time when the energies of the nation are being demanded for a united effort to overcome the serious financial situation. Without any question in our view,

Editorial Comments—continued

these energies should be concentrated on matters of much greater and more immediate importance.

It is unnecessary for us to repeat the arguments which have been put forward, not only in this Journal but in the statements and reports of leading Associations of the shipping and port industries of this country, and we maintain that the Government would be well advised to give more earnest attention to these representations than they have hitherto given and to stop precipitate action before irremediable harm is done to interests which are vital to the national existence.

This Journal has no right to speak on behalf of forms of transport other than those connected and associated with ports and waterways. As regards these, we have to point out that there is no mistaking the unanimity of opinion expressed by all who are versed in port and shipping management and operation, and we contend that their expert judgment should not be outweighed by the superficial views of idealists and political visionaries. A mistaken policy pursued at this juncture may wreck the whole commercial structure of the country.

Clyde Navigation Trust and the Cooper Report.

Some concern has been felt by the Clyde Navigation Trust at the delay on the part of the Government in giving any sign of their intention to implement the recommendations contained in the Report of Lord Cooper's Committee for the formation of a new Port Authority, on the lines of the Port of London Authority, to take over the administration of the Clyde Estuary, and deal with all matters connected with navigational facilities and docks and harbours within the area specified. In making their representations on the Transport Bill, the Trust called attention to the matter and expressed their general approval of the measure, subject to an amendment permitting them to exercise the wide powers proposed to be committed to them under the Cooper Report and restricting the centralised control of the Transport Commission to major policy only. A reply has been received from the Ministry of Transport, confirming a publicly-made statement of the Minister in Edinburgh in February that, " while the Minister can in no way commit the British Transport Commission in advance to any course of action, he considers that it would be very unlikely that they would prepare a scheme without giving considerable weight to the views expressed in the Cooper Report, and without consulting the Clyde Trust and the other port authorities concerned beforehand."

This assurance is stated to have been of the nature of a " favourable reply " in the opinion of the Trust, and the matter rests in the hands of Law and Parliamentary Bills Committee with instructions to the Committee convener and sub-convener, with the Chairman of the Trust, to take further action, if thought necessary, as the Bill proceeded.

We note that the foregoing negotiations took place in the early part of March, and the decision made is presumably somewhat modified by the later appeal of the Liaison Committee of Transport and Industry for a suspense of action in regard to the Bill, alluded to in another comment, to which the Clyde Trust, as a member of the Dock and Harbour Authorities' Association, signatories of the appeal, is a party. Of course, if the appeal fails to have any effect on Government policy, the attitude of the Clyde Trust obviously remains as stated.

Maritime Engineering Research.

Among its attendant evils, the late war, while causing a concentration of research into lethal weapons and implements of warfare, put an end to or, at least, caused a suspension of a number of scientific investigations, the results of which would have been of undoubted interest and value to those engaged in peaceful pursuits. Among these must be included those on maritime phenomena promoted by the Institution of Civil Engineers, the Journal of which in its March issue contains a report on the present position of the research committees and a forecast of their future operations. Of special importance to readers of this Journal are the statements made in regard to the committees on the effect of Sea Action in causing deterioration of structures of timber, metal and concrete exposed to a marine environment, and the committee on Wave Pressures.

The former committee, originally constituted in 1916, carried on its work with the assistance of grants from the Department of Scientific and Industrial Research until 1928, when it became incorporated under the Research Committee of the Institution; it had practically completed its programme with the issue of its Eighteenth Interim Report in 1940. Further observation on the corrosion of metals has, however, since been in progress in the Research Department of Messrs. Hadfields, Ltd., and by Sir William Halcrow and Partners, who are making exposure tests of various steels in West Africa and at the Port of Beira respectively.

Despite the interruption caused by the war, the work on Timber and Reinforced Concrete has been continued. Shortly before war broke out, exposure tests were made on timber treated with a proprietory preservative at Singapore and Colombo. Unfortunately, the specimens at Colombo have been lost, but those at Singapore survived the Japanese occupation, and it is hoped to obtain some useful information from them. As a sequel to the above-mentioned Eighteenth Interim Report, which consolidated the results of experiments on Metals, it is intended to publish a similar report on Timber in the near future.

Wave Pressure was the subject of investigation at the City and Guilds of London College in collaboration with the Department of Scientific and Industrial Research, under the supervision of Professor C. M. White, and an Interim Report was issued in 1939, describing the experimental work so far carried out. A further set of experiments is to be undertaken to determine the magnitude of shock pressures on sea walls, and the conditions under which shingle is deposited or removed by waves from the foot of a wall are to be investigated.

In this connection, readers may like to be reminded of the researches of Brig. R. A. Bagnold, M.A., into Beach Formation by Waves, the results of which were published in our issues of July and August, 1942.

British Shipbuilding.

Amid the general gloom and uncertainty of the present economic position in British trade and its future outlook, a bright gleam is forthcoming from the shipping industry. From a statement recently issued by Lloyd's Register of Shipping on Mercantile Shipbuilding in 1946, it appears that there has been a sharp upward tendency during the year in question, the output of merchant vessels having risen from 898,000 tons in 1945 to 1,133,000 tons in 1946. This total exceeds the immediately pre-war 1938 figure of 1,030,000 tons and is vastly greater than 133,000 tons, the output in 1933, though it is less than the record of 1,284,000 tons attained in 1942, during the war period, when there was great intensity of effort due to the submarine campaign.

The present total represents 53.3 per cent. of the world's output for 1946. Omitting comparison with world totals during the war years, when circumstances were quite abnormal, this compares with 34.0 per cent. in 1938, 34.2 per cent. in 1937, 40.4 per cent. in 1936, 38.3 per cent. in 1935, 47.5 per cent. in 1934, 27.2 per cent. in 1933 and 25.8 per cent. in 1932. Away back in 1913, the ratio was 58.0 per cent.

A New Technical Institution.

A new technical Association was inaugurated in London on March 12th, called the Institute of Navigation, for the purpose of the advancement of the science of navigation, both in the air and at sea. It is a sequel to the inauguration of a similar organisation in America in 1945, with which it is intended there shall be friendly co-operation, as also with all other bodies interested in the improvement of methods and means of navigation for the safety and efficiency of transport.

Navigation is so essentially associated with the use of ports and harbours, that, although the science does not altogether fall within the ambit of this Journal, we feel entitled to express our good wishes for the welfare and progress of the new Institute. Captain G. C. Saul has been elected chairman and treasurer; Mr. Michael Ritchie, executive secretary; and Squadron-Leader D. O. Fraser, technical secretary. It is hoped in due course to publish a journal containing articles by scientists, navigators, and manufacturers bearing on the functions and aims of the organisation.

The Historic Role and Changes of the Loire Estuary

By M. GIBERT, Chief Engineer of Bridges and Highways, France, and Director of the Ports of Nantes and Saint-Nazaire.

THE river Loire, with the Seine and the Gironde, is one of the three great maritime rivers of our country. Accessible to ocean going ships for more than 50 kms. of its course above the bottle-neck of St. Nazaire—Mindin, the Loire has made the fortune of Nantes, the most important western maritime city of France, with a population of 250,000 inhabitants and a great industrial centre for Brittany, Anjou and Poitou. If the Port of Nantes is the main centre of activity on the Loire, it shares this activity with the series of satellite ports of Basse-Indre, Coueron, and Paimboeuf, centre of an important chemical industry for the manufacture of synthetic ammonia, Donges, where large petroleum tankers from Mexico call, and the Port of Saint-Nazaire, which was created during the last century in the estuary of the river and is the largest naval construction port in the country.

In 1937 this series of ports loaded and discharged about 4 million tons of cargo and thus takes sixth place among the ports of France. The river ports, like Rouen, Nantes and Bordeaux, have the common advantage that they allow seagoing ships to convey imported raw materials as near as possible to the centres of production and consumption. They therefore save very expensive land transport, at a small extra cost in navigation. Their economic future is thus assured, within, of course, the nautical limits of access imposed by the river approaches.

This is the reason why these three maritime ports have always made great financial sacrifices in order to maintain constant access for cargo vessels, particularly as regards depth of water, which for them is a crucial problem. Considerable efforts have been made by the Port of Rouen to improve the estuary of the Seine in front of Honfleur, and by the Port of Nantes to transform the Loire into a navigable river; the Port of Bordeaux has made great efforts to solve the problem of its western approach.

Although Rouen and Bordeaux have been able to realise continuous progress during their history, unfortunately this is not the case with Nantes, which almost disappeared from the map as a great port last century, but which, owing to energetic technical measures made such a noteworthy recovery between 1900 and 1935 that the depth of water in the Loire has been increased by 4 metres, the only precedent in maritime records, so far as I am aware, being that of Glasgow.

The history of this accomplishment is that of a brave fight against the elements and against man and is worthy to be recorded. It is bound up, as can be imagined with that of the Loire itself.

Of the three great maritime rivers of France, the Loire presents the engineer with the greatest difficulties. The Seine derives benefit from an exceptional tidal range, 8 metres at Spring tides compared with 6 metres on the Atlantic coast, and it carries very little solid material. The estuary of the Gironde is two and a half times wider than that of the Loire; it stores nearly two milliards of cubic metres at each movement of the tide at high water up river from its narrow entrance, while the Loire with its modest tidal range hardly stores 300 million cubic metres; tidal energy is relatively very feeble, and unfortunately this river has to transport, year in, year out, between 1 and 2 million cubic metres of sand, due to its torrential winter floods from the plains of Allier and the Loire in the centre of France. There is, accordingly, a combination of the most adverse conditions: copious supplies upstream and feeble tidal impulse. The natural conditions are thus unfavourable for navigation, but they sufficed in former times, and did not hinder the Ports of Nantes and of Bordeaux from becoming the main ports of the country in the age of sail.

*An Address delivered to the Association of Large French Ports by the Author on 8th May, 1946. Translated by Rolt Hammond, A.C.G.I., A.M.I.C.E., from an article entitled "Role Historique et Transformations de la Loire Maritime," originally published in the August, 1946 issue of *Travaux*.

For centuries the prosperity of Nantes did not depend on local industry, but on that of the whole valley of the Loire and even upon that of a large part of Europe. Goods came from the great fairs of Champagne, Perpignan, and Lyons, reaching the sea by the Loire. The towns along its banks were mostly warehousing depôts, some for the shipment of local products and others for the reception or transhipment of produce of distant origin.

According to a document in the national archives, the Port of Nantes handled the largest volume of shipping in 1704. It shared this leading position with Bordeaux for the whole of the eighteenth century. Vessels fitted out for the African trade exchanged their cargoes for negroes and gold dust, sold the negroes in the Antilles and bought coffee, cotton, cocoa and sugar cane there for the refineries already established in the Nantes district; other vessels took manufactured products directly to the Antilles. Wines, salt and colonial products found a large re-export market in Nantes for the other ports of France, of Holland, and of Spain. In 1764, of 458 vessels sailing from Nantes, 107 went to Holland, 106 to the Antilles, 87 to other French ports and 42 to Spain.

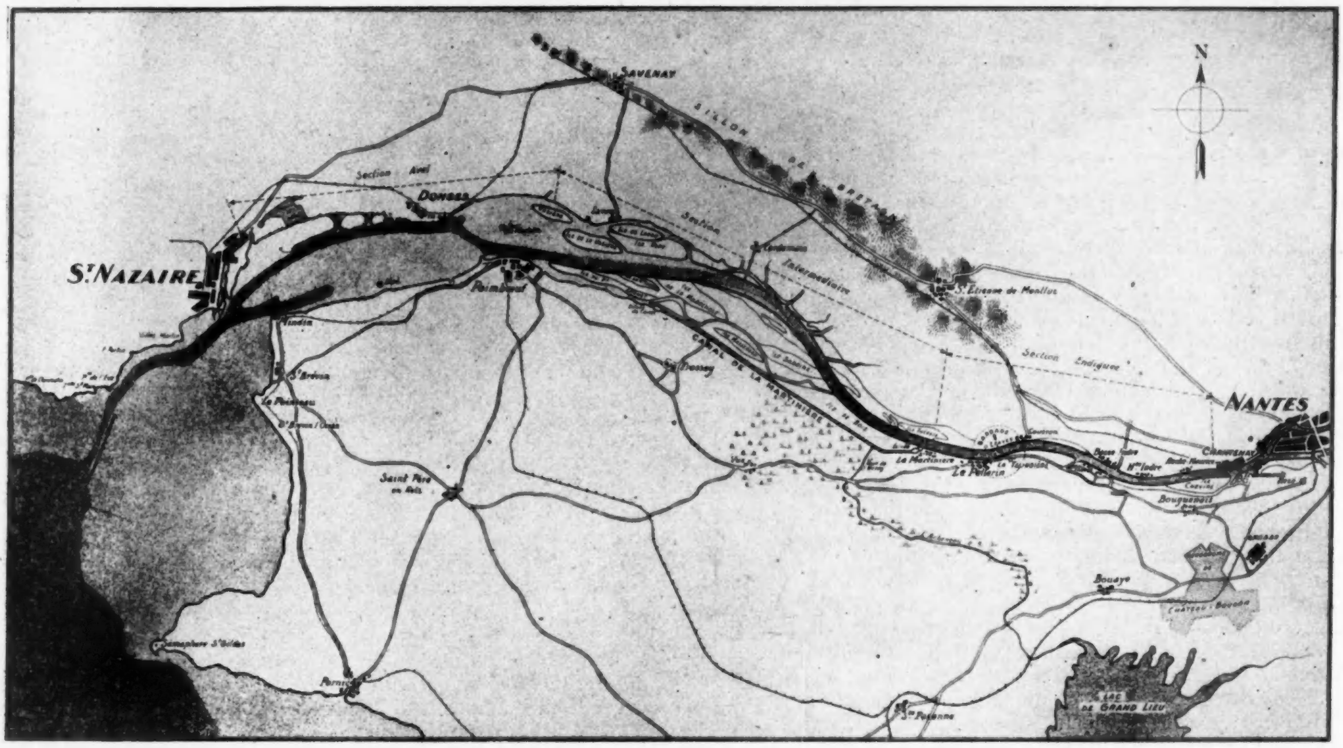
There was a shadow hanging over this picture of prosperity, which rapidly became a menace at the beginning of the nineteenth century in the form of silting up of the river; in 1663 the merchants of Nantes prayed the king to proceed with " the clearing of the river from Paimboeuf to Nantes to allow vessels of from 4 to 500 tons to proceed up the Loire." In 1698 the Intendant of Brittany reported: " The large vessels can only reach Paimboeuf, where their cargoes are loaded into lighters for transport to Nantes." The Duke of d'Aiguillon, appointed Lieutenant General of the province of Brittany in 1756, was also concerned with the problem of the Loire and ordered the naval engineer Magin to carry out the first dock works.

The Revolution, followed by the Continental Blockade, cut off the foreign trade so that it no longer came to Nantes. With the return of free trade the era of coal and machinery dawned, steam navigation replacing sail. Meanwhile the spirit of enterprise was not lacking in Nantes. In 1817 M.Dobrée fitted out a whaling ship, and the former connections with the Antilles and with Réunion were resumed. Three-masters traded with China and with the West Indies, but at the beginning of 1840 the depth of water in places in the Loire was less than 3 metres, and the compulsory transhipment of cargo from large vessels to lighter at Paimboeuf represented a heavy expense. The maritime Loire had temporarily ceased to satisfy the requirements of navigation.

On the other hand, the river portion of the Loire, prolonged by the canal from Nantes to Brest (begun in 1806 by Napoleon and finished in 1842), also sought to adjust itself to this change in transport methods. Vessels on the Loire changed with the times, but all were of light draft, due to the shallow depth of water and were only occasionally decked. Under the old regime there were barges of 30 metres length, having a beam of 4.50 metres and a maximum draft of 1 metre; the rafts of Roanne drew no more than 40 cms. These were built some distance up river and made regular voyages to the coast, loaded with coal from Saint Etienne, or with timber for burning or to be used in building work; they never returned, for on arrival at Nantes or Angers they were broken up. Veritable chains of sailing lighters used to come down the river.

At the beginning of the nineteenth century the Loire, which began to feel the first effects of improved land transport, took on a new lease of life. Important freight was provided by the excess oil production from Saint Etienne. The first steam vessels came into service, such as the Hirondelle, the packet boats and a steamship company. In 1855 four steamship lines plied between Orleans and Nantes. At this date the traffic attained almost the same volume as that between Paris and Rouen; it was considerably greater than that of the Rhone or of the Rhine. The Prefect of

Changes in the Loire Estuary—continued



General Plan of the Estuary of the Loire.

the Department was already beginning a service of light draft vessels to connect the Loire with these two rivers.

Railway competition then came into the picture. Attempts at co-ordination with rail transport were made at the outset, before the railway had reached the outer limits of the provinces. In 1846 the Orleans Railway Company bought the steamship line operating on the Loire and these vessels ceased to ply.

The Loire gradually became deserted. Could this decline in maritime trade be attributed to progressive silting? We do not think so. Observations of old works and of bridge foundations do not lead to this conclusion. It is necessary to point out that navigation has always been difficult. Even Caesar advised his lieutenants in Gaul to build lengthy ships to avoid stranding on the shoals of Loire. The Marquise de Sevigné has stated: "The sand is more treacherous than Scylla and Charybdis—the channel constantly varies and the water frequently fails . . . it is foolish to embark."

In the eighteenth century accidents to shipping were so frequent that the insurance rate for cargoes between Nantes and Orleans was greater than that charged between Rouen and Holland or Hamburg. For centuries the Loire has been a valuable commercial artery, even in spite of the navigational risks and the small displacement of the vessels. It could not, however, compete with the railway, which was more regular, faster and safer. Only a branch canal would revive it, if new industrial enterprise could justify the cost of its construction.

The nineteenth century was therefore a difficult period for the Port of Nantes, the decline f which seemed inevitable, with the traffic of the river portion of the Loire decaying on the one hand and the maritime portion of the river becoming impossible for navigation on the other. There appeared to be no remedy for this state of affairs, since the technique of those days was not capable of improving the unfortunate natural state of the river. It was a long time before the channel could be remodelled and the islands removed.

The idea of creating a great port at the mouth of the Loire, capable of saving the trade of Nantes, was put forward in August, 1808, when the Emperor Napoleon appointed two engineers, Messrs. Sganzin and Prony, to study the problem. They reported that the project to improve the river in front of Nantes should be abandoned and recommended the construction of a quay at Paimboeuf and a new port at Saint Nazaire, at that time merely a humble fishing village.

The Imperial Government was soon faced with other more pressing problems, but after the fall of the Empire there was spirited rivalry between the inhabitants of Saint Nazaire and those of Paimboeuf; many questions were raised by the Consul General and the Chamber of Commerce of Nantes, which led to a new technical inquiry. This finally resulted in a Ministerial decision of the 21st April, 1838, to create the Port of Saint Nazaire, which thereafter made great progress.

Plans for a basin with an area of 20 hectares were approved in 1845, the first vessel entering Saint Nazaire in 1856. These works cost 8,920,000 francs. Shortly afterwards, the railway line between Saint Nazaire and Nantes, later bought by Paris Orleans Railway Company, linked the two ports together by rail.

From the beginning, the trade of Nantes reflected the lack of dock facilities, and in 1861, four years after the opening of the port, an Imperial Decree ordered the construction of a second basin, at Penhoet, declaring this to be an important public work; its area was 23 hectares and the work was completed in 1881. Meanwhile, the almost entirely modern town of Saint Nazaire had grown in mushroom fashion like certain American concerns, stimulating keen speculation in real estate.

As for maritime traffic, it increased beyond all expectations; in 1860, 277,000 tons of goods passed through the port; in 1870, 617,000 tons; in 1890, 1,658,000 tons and during the next decade it increased until it had become 1,936,000 tons in 1900. Thereafter it was maintained around the two million ton mark, reaching the exceptionally high level of 3.694,000 tons in 1918, due to the fact that it was an American military base.

Terminus of the General Transatlantic Company for Central America and a great centre of naval construction, Saint Nazaire became very prosperous. A bitter struggle took place between the Ports of Nantes and Saint Nazaire and in 1873 the Chamber of Commerce of Nantes published a report about the proposed con-

Changes in the Loire Estuary—continued

struction of a second basin at Saint Nazaire, in which they declared: " We will never admit that the Consul General of Loire Inferieure has the right to impose an agreement of twenty years upon the commerce of Nantes, from which Saint Nazaire will draw the exclusive advantage, and which appears to imply the abandonment of the maritime Loire and the abandonment of the Port of Nantes . . . " Some years later, in 1879, the idea of a Chamber of Commerce at Saint Nazaire became an accomplished fact.

The new attitude adopted by the Chamber of Commerce of Nantes, entirely hostile to the Port of Saint Nazaire, in the development of which the Chamber had played a leading part, was based on the new conviction that there was a reasonable chance of improving the state of the river even in spite of the meagre results achieved in 1840. The level of the channel bed in what was termed the intermediate section, dotted with sandbanks and islands, was always greater than 50 centimetres above the zero datum on the charts, giving a draught of only three metres at high water neap tides.

The Loire owes its revival to the eminent engineer Lechalas. He was a veritable pioneer, for he laid down the guiding principles governing the improvement of tidal rivers, which have today become standard practice. Lechalas proposed the following works:—

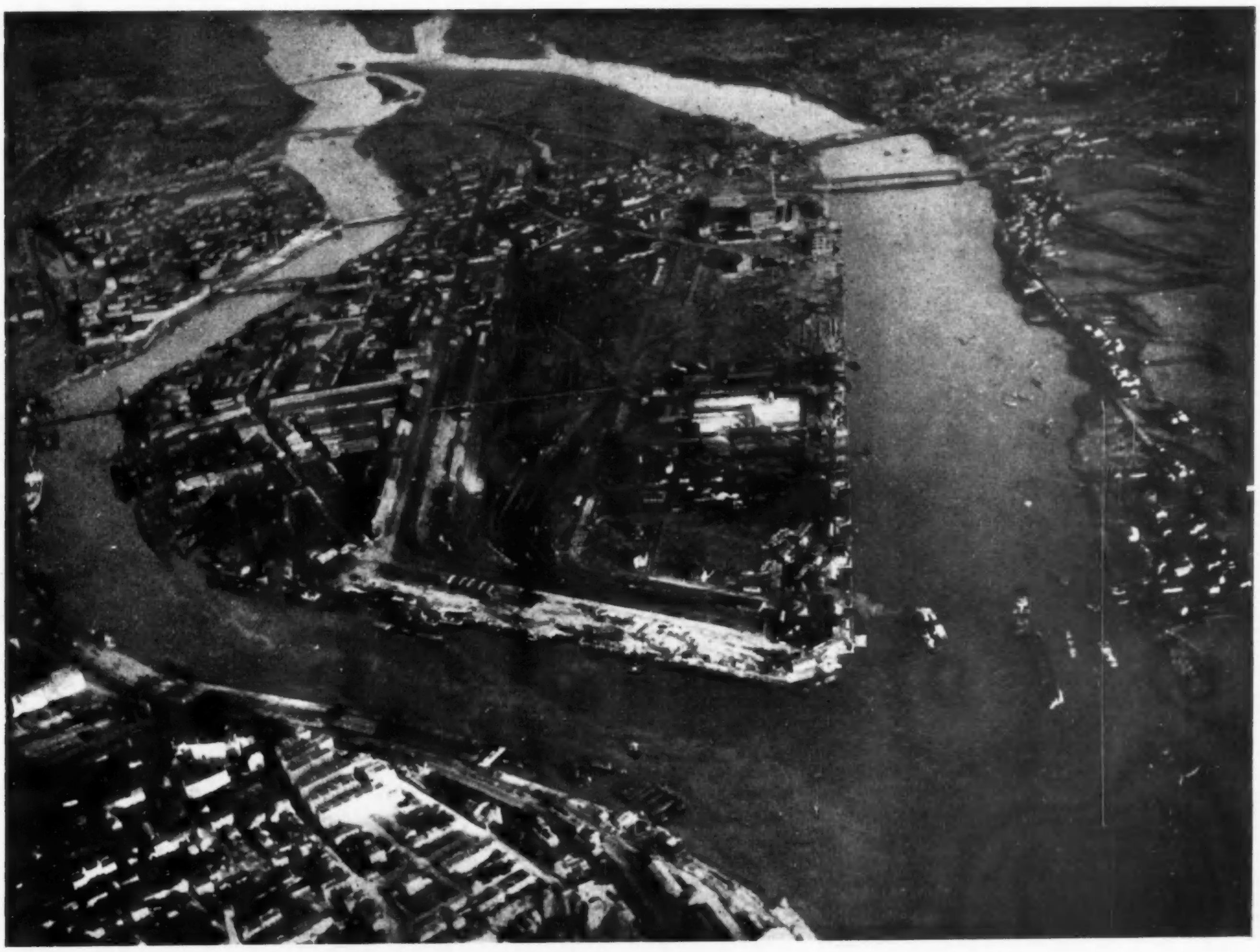
(1) To remove all the islands obstructing the bed of the river, so as to form a single funnel-shaped channel with its mouth open towards the sea, in order to facilitate the entrance of the flood tide and thus to transform the lower Loire into a river without islands, confining its course between regulated banks.

(2) To dredge the bed of this channel in order to lower by at least two metres the level of low water at Nantes.

In order to maintain this depth it would be necessary to dredge some five million cubic metres of material, a large quantity for those days. Lechalas was able to quote the rapid transformation of Glasgow as an example of what could be done. Owing to methodical dredging in the river Clyde, the depth at low water had been increased from 50 cms. to 3.75 metres, at the same time that the tidal range had mounted from 0.65 metres to 2.60 metres and the available depth at high water increased from 1.15 metres to 6.35 metres, thereby allowing the access of 4,504 steam vessels to the port in 1865.

As we see today, the active collaboration of the two ports of Nantes and of Saint Nazaire is realised under the aegis of a Commission of the Maritime Loire. The project of Lechalas was thought at the time to be expensive and riskly. Many engineers, ignorant of the example of Glasgow, did not believe that it was possible to deepen the river and that Lechalas and Partiot "asked more of the Loire than it was able to give." Other engineers, such as those of Saint Nazaire, maintained that this undertaking would set in motion huge quantities of sand which would interfere with access to the Port of Saint Nazaire.

At the time it was thought that no improvement could be effected on the Loire, whereas the campaign in favour of the revival of the Port of Nantes had borne fruit in the form of a lateral maritime canal, which was included in the public works programme of Freycinet. This canal is a fine work which cost 26 million gold francs. The opening ceremony took place on the



Aerial View of the Port of Nantes

Changes in the Loire Estuary—continued

1st September, 1892; a six metre depth of water was provided and there was rapid development of the Port of Nantes, which handled 350,000 tons of goods in 1886, passing the million ton mark in 1900.

It soon became evident that the port was inadequate, and in 1900 the Administration instructed its engineers to report on the works which would be necessary to ensure that vessels drawing six metres, seven metres and even eight metres could reach Nantes at all states of the tide, comparing the solution of the improvement of the river itself with that of the deepening of the canal.

Dam of foundered craft at Telindieu. Deviation Scheme for the river and provision of a cofferdam round the craft.

The Commission charged with examining these proposals was almost unanimous in preferring the river project, expressing regret that the ideas of Lechalas had not been put in hand sooner. It is true that in the interim the technique of dredging had made great progress and the small dimensions of the Loire facilitated the application of mechanical treatment.

It was a resounding success. Not only was a depth of six metres very easily obtained, but even seven metres. The low water depth at Nantes was lowered more than 1.50 metres, and the level of the channel, which was 50 centimetres above zero datum in 1900, increased successively to minus 1.20 metres in 1910 to 2.40 metres in 1914 and to 3.70 metres in 1937.

From 1910 the use of the maritime canal was practically discontinued. As if by the waving of a magic wand, the maritime Loire was transformed and the Port of Nantes was saved. It is quite usual for vessels drawing seven metres to go up river at all states of the tide and those drawing eight metres at spring tides.

Progress has naturally been delayed by the second world war, and the depth of water has been temporarily reduced by one metre, owing to the presence of mines and of wreckage. In the near future, however, when the initial phase of reconstruction has been completed, we can hope that the new works will permit vessels drawing eight metres to ascend the river on all tides, and not only at springs. Naturally, with increasing requirements the improvement works are more difficult and more expensive and progress is slower. If it was easy to gain one or two metres at the beginning of the improvement works on the maritime Loire; each additional gain of a foot requires more and more effort as one approaches the natural possibilities of the river. However, there is still something to gain in the Loire, the longitudinal section of which has not yet attained a line of equilibrium as in the case of the Gironde. Only experience will show what is practically possible.

The increase of traffic has been closely in step with the progress of the improvement works in the maritime Loire, the Port of Nantes recovering its former trade, as prophesied by Lechalas. Traffic had increased from a million tons in 1900 to two million tons in 1913 and to three million tons in 1937.

Imports include solid and liquid fuels, pyrites and phosphates, colonial products; exports comprise iron ore from Anjou and artificial fertilisers, which are manufactured locally.

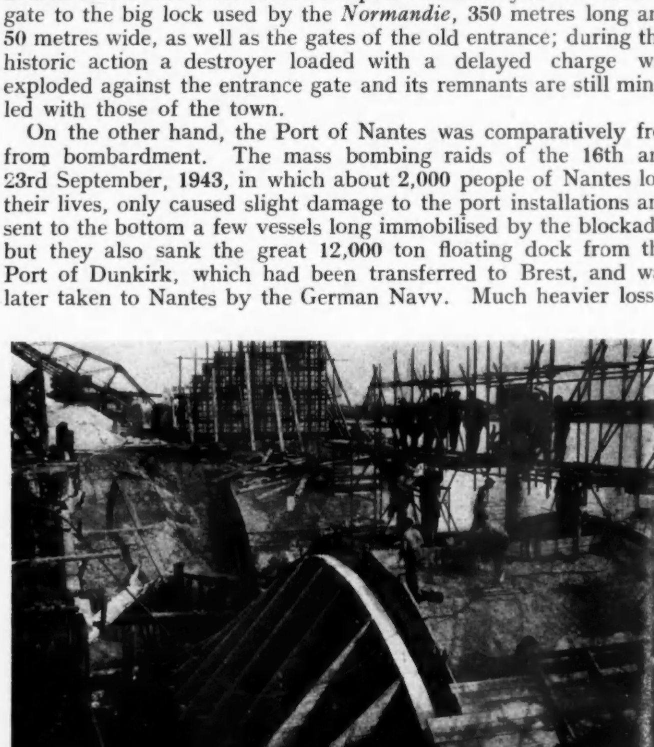
As for Saint Nazaire, its traffic has declined considerably since 1918. The return of general cargo to Nantes, the electrification of the Paris Orleans railway system with a consequent reduction of coal imports, and the closing down of metallurgical works on the Lower Loire have been very unfavourable factors.

A renewal of prosperity has taken place as a result of the trade brought to the port by the Liberty type of vessel. Such ships, and the importance of local industries capable of being greatly extended, such as shipbuilding and aircraft manufacture, will confer upon Saint Nazaire an important role on the Maritime Loire, without in any way affecting the prosperity of Nantes. Only a radical change in naval architecture, which seems unlikely in view of the construction plan now under way, would be able to upset the balance if a considerable increase in the draught of cargo ships were to have an adverse effect on the position of the river ports.

Reconstruction of the Ports of Nantes and Saint Nazaire

The ports of the Maritime Loire paid a very heavy price during the war. For the period 1942-44 Saint Nazaire was transformed into a German military arsenal and submarine base, and was the objective of repeated allied bombing attacks, which flattened all its buildings. On the night of the 27th-28th March, 1942, a British commando force raided the port and destroyed the entrance gate to the big lock used by the *Normandie*, 350 metres long and 50 metres wide, as well as the gates of the old entrance; during this historic action a destroyer loaded with a delayed charge was exploded against the entrance gate and its remnants are still mingled with those of the town.

On the other hand, the Port of Nantes was comparatively free from bombardment. The mass bombing raids of the 16th and 23rd September, 1943, in which about 2,000 people of Nantes lost their lives, only caused slight damage to the port installations and sent to the bottom a few vessels long immobilised by the blockade, but they also sank the great 12,000 ton floating dock from the Port of Dunkirk, which had been transferred to Brest, and was later taken to Nantes by the German Navy. Much heavier losses



Port of Nantes. Reconstruction of the Wilson Quay, 1946.

resulted from the allied bombing raid of June, 1944 in Normandy. Shortly after the beginning of these operations, it became clear that the Germans were planning complete destruction of the port, in addition to sabotage of all the dredging equipment in the Maritime Loire. This included seven bucket dredgers, two suction dredgers and three gun boats, increased temporarily by the following units brought from other ports after the disaster of 1940: the dredger *Pas-de-Calais II* of Boulogne, hopper vessels, the stationary dredger *Fatouville* of the Port of Rouen, recently com-

Changes in the Loire Estuary—continued

pleted at Nantes and the suction dredger *Pierre Lefort* of the autonomous Port of Bordeaux.

After the break-through at Avranches and the capture of Rennes in the beginning of August, the hope of early deliverance put new heart into everyone. Unfortunately for Nantes the allied push halted some considerable distance from the Loire, in order to turn sharply to the east in the direction of Le Mans and Paris. The Germans profited by this respite to hasten their plan of destruction in order not to leave the leading port of France, after Cherbourg, to fall into allied hands. Envoys were therefore sent to allied headquarters to stress the need for avoiding huge destruction by early intervention and at the same time all possible measures were taken up to the very last moment, both by the local German command whose promises were more or less sincere and by the Fighting French forces, who hoped to be able to provide armed help at the critical moment. All these efforts were in vain, the first allied troops entering Nantes on the 12th August, 1944, after the Germans had voluntarily evacuated the town, but not until they had carried through their plan of destruction with special units. Only the Roche Maurice quay, 500 metres long, was saved, owing to the failure of the mines laid there to explode, the cause of which is still unknown.

Port of Nantes. Quays on the right bank restored at the end of 1946. Naval construction in the background.

In forty-eight hours the Germans inflicted damage amounting to some two milliards of francs on the ports of the Loire, which includes the value of quays, machinery, vessels and bridges in and around Nantes. The gaps in the quays totalled 1,500 metres in length; the Wilson quay, 1,400 metres long, was destroyed in addition to 60 per cent. of the public quays with a total length of 4.50 kms. without taking into account the damage to subsidiary works. Fortunately the Roche Maurice quay was intact as well as the private quays, which provide some 800 metres of wharfage. As for machinery, only eight cranes remained in working order at the time of the Liberation out of a total of 93 public and 20 private cranes, but 54 were able to be repaired; 31 were completely destroyed. It was estimated that only 20 per cent. of the dock sheds were usable. Every bridge in Nantes was destroyed.

All vessels and floating machinery had been judiciously wrecked; I say judiciously, because the placing of the charges had been carefully studied to produce the utmost possible damage. In all, 121 vessels of various types were destroyed, which included 36 ships of different sizes, the 20,000 ton oil tanker *Palmyra*, the Belgian packet boat *Baudoinville*, 20 tugs and 26 of the finest dredgers in France. They were placed in such a manner as to neutralise certain quays which remained intact or to block the channel. In particular, a number of vessels were concentrated at a place called La Telindiére, 15 kms. from Nantes, and at Lagrange near Bordeaux.

This barrier included the large whaling ship *Antarktis*, the dredger *Fatouville*, the dredger *Pas-de-Calais II* a bucket dredger and a suction dredger from Nantes, a gun boat, a naval sloop, a tug and a lighter. The channel was reduced by 50 per cent. and all navigation was completely paralysed; it should be added that there were also a number of acoustic and magnetic mines laid near Saint Nazaire, which remained in enemy hands until the capitulation on the 12th May, 1945.

The capitulation saved a great deal of possible destruction in Saint Nazaire, but the port was nevertheless in a sorry state, the basins filled with debris, the quays badly damaged and extremely difficult to repair, without machinery, dock sheds or tugs, the town itself almost completely destroyed. Bomb craters, masses of twisted steelwork, innumerable blockhouses, completely destroyed dockside railways, and tons of abandoned munitions in disorder was the picture which greeted us when we once more took charge of the port. It was opened to traffic three months later on the 12th August, 1945, and handled a cargo of pyrites from the *Paul de Rousiers*.

How do we stand on the Loire, eighteen months after our Liberation? Since Saint Nazaire was liberated six months after Nantes, it was only natural that the latter port should receive priority of repair. The first essential was to restore, first temporarily and then permanently, land communication between the two banks of the Loire at Nantes, or rather between four banks, because here the river is divided into two arms. This task fell to the Marine Service. On the north arm the Madeline and Haudaudine bridges were repaired; on the south arm a temporary two lane road 300 metres long was built to take a load of twelve tons in the midst of military operations, when tanks weighing 35 tons passed over it. The steel bridge at Pirmil was rebuilt, using only 400 tons of new material out of a total of 2,200 tons. This work still continues.

The clearing of debris was the responsibility of the Port Director, who divided this work between the Service of Bridges and Highways and the Navy. Since means were lacking to carry out this work, it was necessary to construct tugs, a 30-ton floating shear legs and two pontoons fitted with shear legs of 100 tons capacity. A force of 600 men, of whom 50 are afloat, are dispersed throughout six concerns, and are provided with a varied assortment of pumps, compressors, dredgers converted to excavators and other machinery, which together is an impressive array of plant enabling the engineers of Nantes to obtain excellent results. At the end of 1945 about 100,000 tons of steel had been recovered, together with more than 90 vessels, which included all the tugs in addition to 19 dredgers. The basins at Saint Nazaire are clear and the Port of Nantes is almost entirely free.

The Port of St. Nazaire restored after the Liberation in the Summer of 1946.

A great deal yet remains to be done, even at Nantes, to raise the floating docks of 4,200 tons (belonging to Nantes) and of 12,000 tons (belonging to Dunkirk), which are extremely difficult to handle; another task is to solve the problem of the two great barriers, one at Telindiére, of which we have already spoken, and

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Changes in the Loire Estuary—continued

the other at Aiguillon in the estuary of the Loire. The latter had been prepared by the Germans to deal with a possible allied attack on Saint Nazaire, and was provided with an entrance 80 metres wide which would have been shut at the last minute by the scuttling of an oil tanker, kept in reserve for the purpose. We were spared this closure by the capitulation and navigation is once more free, but the entrance remains narrow and pilots complain. As soon as funds allow, it must be cleared completely.

On the other hand, the barrier at Telindiére was complete. In order to open an 80-metre gap in this, it was necessary to blow up two small vessels and a dredging service tug and to cut off the stern of the whaler *Antarktis*. This task was rapidly carried out at a cost of less than ten million francs and the channel was ready for navigation as soon as the Saint Nazaire pocket had been cleared. A very interesting feature of this barrier was that the cross sectional area of the anchorage portion of the Loire was reduced from about 2,000 to 1,000 square metres. This reduction of section, as well as the strong floods of the winter of 1944-45 caused very swift currents which caused the *Antarktis* to settle 15 metres aft and 10 metres forward. It should not therefore be necessary to raise the whole wreck in order to establish normal depth of channel.

Reconstruction of the quays at Nantes is also well advanced. It was started in the middle of last year, as soon as materials became available. The problem of steel supply was solved by drawing on German stocks in the Saint Nazaire pocket and timber was obtained from the forests of Landes.

Up to August, 1946, 850 metres of damaged quay at Nantes had been reconstructed, in which 4,000 tons of cement and 1,500 tons of steel reinforcement have been used. Dredging of debris in front of this work has been completed.

At the same time quays on the right bank at Fosse, Ernest-Renaud and Aiguillon will be restored, increasing the mooring points from 11 to 30. The port had only eight cranes in operation at the time of the Liberation and at present it has 44, 11 under repair and 15 shortly to be repaired, which will soon be increased to 70 in addition to more than 20 private cranes. This will make Nantes one of the best equipped French ports after Bordeaux, miraculously spared any damage.

Dredging equipment has been partly restored by three bucket dredgers, a suction dredger which will soon be lent to the autonomous Port of Bordeaux, eight tugs and 40 lighters. A Canadian dredger under repair is expected shortly as well as a hopper vessel, salvaged with great difficulty.

Meanwhile it will not be possible to restore the pre-war depth of water to Nantes for about two years (7 metres at neaps and 8 metres at springs). The muddy pools at the quays, which had not been cleared for several years, are badly silted up, similar conditions applying at Bordeaux. The state of the channel in the Loire has not changed much, and moderate dredging will restore it to its pre-war state, when the neutralisation of mines will permit work to be carried out on the intermediate section and above all when the barrier at La Telindiére has been completely cleared and when the displacement of the river no longer compels ships to follow a devious course; it is the same problem as that of the Gironde on a smaller scale. While waiting for this work to be finished, we must resign ourselves to a loss of two or three feet of the pre-war depth except at Donges, which will be accessible within one month to oil tankers drawing nine metres at all states of the tide.

It is very fortunate that the maritime Loire has a fine outer harbour, Saint Nazaire, accessible to the Liberty type of vessel drawing 8 or 9 metres. So far Saint Nazaire has handled cargo from 72 ships of this class.

A great deal of debris has been cleared and sheds are being built over an area of about 10,000 square metres. Cranes which could be repaired have been put into action, eight of five to ten tons for heavy loads and eight others for mixed cargo, of which three have been lent by the Chamber of Commerce of Nantes. There are five berths for large ships, soon to be increased to nine; there is enough accommodation for about a million tons of coal a year.

Among the works under construction, the most important is that of restoring the harbour entrance. The masonry is intact, but all equipment must be rebuilt. A great problem is the reconstruction of the gates, each weighing 1,200 tons and worth 70 million francs. The upstream gate appears to be repairable. A suitable gate to replace the existing downstream gate is at present in the American zone of Germany, near Frankfort, and this will have to be bought from the Americans. This work is of great importance, since it will allow large vessels drawing nine metres to obtain direct and easy access to the best moorings, and will enable exceptionally large ships to be repaired in the extensive shipyards of the port.

It is hoped that the present unsatisfactory state of our public finances will not have an adverse effect on the reconstruction of our ports, and in particular on the works at Nantes and at Saint Nazaire, where I am afraid that the pace may be slackened. These ports have played only a modest part since the Liberation, but the increase of maritime traffic in the Loire has been by no means negligible, and has been shared equally btween Nantes and Saint Nazaire, at an average of about 150,000 tous a month between them. The possibilities of the Port of Nantes would have been better exploited if the United States War Shipping Administration had arranged for the access of Liberty ships after improving the entrance to Saint Nazaire. In many cases this would have been a considerable advantage for cargo. But certain objections, the main one being the danger of mines, have not yet been overcome. Whatever may be the case, this is a transitory phase, and there is no doubt that Nantes, in collaboration with Saint Nazaire, will take its due place in the national economy.

The two ports did not fulfil the pessimistic prophesies made in 1881 by an eminent hydrographic engineer, Bouquest de la Grye, whose grim forebodings possibly led to the creation of the Port of La Pallice. For twenty years he had been studying the changes in the bed of the maritime Loire and had discovered progressive silting. "Under these conditions" said he, "Nantes will be lost, but how can even Saint Nazaire live—it would be an illusion to believe it. The existence of this port at any time depends upon the height of the outer bar and of the permanence of the depth of water in front of the town. If in the period from 1881 to 1898 this bar rises as much as it has done during the last 17 years, the fate of Saint Nazaire is certain. Does one build a maritime port for the limited period of a century? Evidently not! Saint Nazaire, a recent creation, ought not to vanish like certain oriental towns. It should be noted that both Nantes and Saint Nazaire have absolutely identical interests, their existence depending upon the river. Saint Nazaire is not a seaport as a sailor understands the term, but a river port; this is proved by the safely of the roadstead during S.W. Winds, and a better proof still is the presence of a downstream river bar." "Nantes," he added, "can only hope to save itself by means of the canal which the Chamber of Commerce has been given by the Government."

Today the Charpentiers Channel, newly dredged by the *Pierre Lefort*, has depths varying from 8 to 9 metres below low water and maintains itself naturally. The interests of the two ports have a common basis, the Loire, which finds expression in the newly created Commission of the Maritime Loire under the presidency of M. Tartrat, Inspector General, and I trust that this will play an important part in the future development of these two ports.

Canadian Port Facilities

At the annual general meeting of the Shipping Federation of Canada, which was held at Montreal recently, Lt.-Col. I. H. Eakin, the President, called attention to the urgent need for labour improvements and said that last year the Federation placed before the National Harbours Board, Ottawa, their recommendations for improved harbour facilities at all the larger Eastern Canadian ports, to the end that existing and anticipated export and import traffic through those ports might be handled without delay to vessels, whose daily costs were now a matter of concern to all ship operators. It was their hope that this year the Canadian Government, acting through the National Harbours Board, would inaugurate a programme of harbour improvements to ensure that these Canadian channels of export and import trade would not lack the necessary modern facilities for handling such trade efficiently.

Ice Blockade of Canadian Ports

The Winter Temperature Cycle of the St. Lawrence Waters A Plea for More Data*

By J. G. G. KERRY, M.E.I.C.

(Continued from page 276)

Surface Temperatures

For ten years past the staff of the Dominion Meteorological Survey under the immediate direction of Mr. F. S. Millar has been recording the surface temperature of the Great Lakes, placing time-temperature recording instruments on various vessels making commercial runs and particularly on the car ferry operated by the Canadian National Railways between Cobourg and Charlotte. A partial summary of results is given on Figs. 2 and 3, which show lake surface temperatures:

(a) Five winters' lake temperatures on the run across Lake Ontario from Cobourg to Charlotte.

(b) Three sets of observations of lake temperatures on Lake Superior in the late fall on the run between Port Arthur and Whitefish Point and two sets in the early spring.

(c) One winter's temperatures on the run across Lake Michigan from Milwaukee to Muskegon as observed by Mr. Church.

It is not certain that the temperature equalisation discovered by Mr. Church extends to the bottom of the very deep lakes such as Ontario and Superior. On Fig. 6 are shown a series of deep lake water observations[5] recorded by Mr. Fitzgerald, particulars of which are as follows:—

Curve A shows a series of observations made on Lake Superior for the U.S. Lake Survey in August, 1871. The readings were taken at various places and on various dates. Curves B, C and D show a sequence of observations made in 1848-49 by Messrs. Fischer, Ooster & Brunner in Lake Thun, Switzerland. Lake Thun very rarely freezes over but it will be noted in Curve D that temperature equalisation has descended to a depth of 500-ft. The month and day of the observations are shown by Roman and Arabic numerals, respectively. Curves E and F show observations made by F. A. Forel in 1879 on the Lake of Geneva which never freezes over. Curve F shows that the temperatures have equalised to a depth of 900-ft.

The Swiss Lakes are much smaller and much better protected from wind by the surrounding mountains than are the Great Lakes of North America. For purposes of comparison, average surface temperature curves for Lake Superior and for Lake Michigan-Huron are also shown on Fig. 6. The data for these average curves are taken from a paper prepared by Lieut. Hickman[6] of U.S. Lake Survey and presented to the American Society of Civil Engineers in 1939.

From the preceding discussion there emerges the engineering problem of regimenting the outlets of the various Great Lakes so that the outflowing rivers will draw their supply from deep and " warm " waters in the parent lake.

Rate of Cooling-off

The rate at which open water under Canadian winter conditions will give up its heat is difficult to determine, because the geophysical forces which are in action are very sensitive to atmospheric conditions and their effects quantitatively change rapidly and materially with variations in wind, cloud and haze. This makes observational records of little value unless they are continuously maintained. The geophysicist's approach to this problem is discussed briefly later on in this paper.

*Paper presented at the Sixtieth Annual General Meeting of the Engineering Institute of Canada, at Montreal on February 8th, 1946, and reproduced by permission.

Such records as are available of direct observation of the rate of cooling-off are in fair agreement if it is assumed that the difference in temperature between the air and the water surface is a measure of the rate of loss. This assumption is not tenable for any long period of time, for there are great geophysical forces at work which are practically independent of changes in the temperature of the air.

The scientifically accurate measurements of Dean Birge and Associates in Lake Mendota[3] show that that lake during the month of November has a uniform temperature at all depths and is cooling-off rapidly. The average depth of Lake Mendota is 40-ft. and the average fall of the water temperature during November was from 52.5 to 39 degs. F. The average air temperature is 36 degs. F. The average heat loss per sq. ft. of surface per day was therefore about 1125 B.T.U. or roughly 115 B.T.U. per sq. ft. per day per degree of temperature difference between air and water.

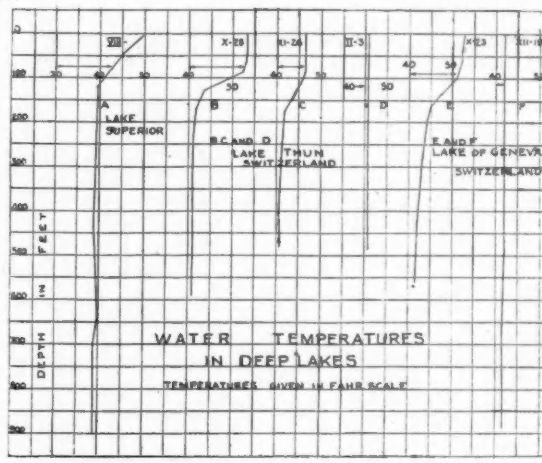


Fig. 6.

Calculations using the geophysical formulæ discussed further on in this paper indicate an average heat loss of about 1175 B.T.U. per sq. ft. per day as likely under average weather conditions at Lake Mendota in November.

The Joint Board of Engineers in their 1926 Report to the International Waterways Commission lists twelve series of measurements made in the early part of December on the St. Lawrence River below Kingston, each experiment extending over ten or eleven days. The results range from a constant of loss per sq. ft. of surface per degree difference of temperature of 83.0 to one of 121.7 and the Joint Board recommends the use of a constant of 95 B.T.U. A plotting of the published results suggests that possibly the governing equation is not a straight line but should flatten off as the amount of the temperature difference increases.

Strictly speaking, the above constant should be applied only to conditions as they are found in the early part of December in any year on the St. Lawrence River.

It may be noted in passing that the curves of the average air temperature during the winter months as taken at Madison, Wisconsin, and at Kingston, Ontario, are in close agreement, and that the two sets of observations of heat loss are in reasonable agreement with each other and with geophysical theory.

Ice Blockade of Canadian Ports—continued

The measurements taken by Mr. P. Church, gave the results shown in Table I, calculations being based on an average depth of 300-ft. for Lake Michigan, and the waters in both shore areas being excluded from the calculation. The air temperatures are not definitely known and those used in the calculations are based on the records of nearby land stations as given by Mr. Church slightly modified by reference to the long-time records of Madison, Wisconsin.

Surface and Frazil Ice in the St. Lawrence River

TABLE I

Heat losses from the surface of Lake Michigan in the winter of 1941-1942 calculated from observations taken by P. E. Church:

Dates	Temp. Drop (°C)	Daily Av. Drop (°C)	Daily Av. Drop (°F)	Loss of Heat on B.T.U. Per Sq. Ft. Per Day
Dec. 15 to Mar. 21 ...	3.18	0.035	0.063	1181
Dec. 7 to Dec. 19 ...	0.55	0.046	0.083	1556
Dec. 19 to Jan. 27 ...	1.94	0.05	0.09	1698
Jan. 27 to Mar. 4 ...	0.94	0.026	0.047	881
Mar. 4 to Mar. 21 ...	0.23	0.013	0.023	431
Mar. 15 to Mar. 21 ...	0.05	0.009	0.016	300

It will be noted that the loss constant falls off sharply as the winter progresses and this is in good agreement with geophysical theory. It is clear that, if the waters of a Great Lake such as Ontario remain consistently at a temperature well above freezing point, the maintenance of an open outflowing river is simply a matter of heat conservation. As Mr. John Kennedy knew sixty years ago, and as Dr. Barnes has pointed out again and again, water will not form ice until it is cooled down to freezing point. To keep the water in a river warm, its channels must be as narrow and as deep as can be secured. The St. Lawrence River would flow comfortably in a channel about 1,500-ft. wide and 64-ft. deep with a regulated velocity of about 2 miles per hour.

What this means may be illustrated by reference to the report of the Joint Board of Engineers from which the figures in columns 1, 2 and 3 of Table 11 are taken.

TABLE II

Comparison of actual heat records in the St. Lawrence River with obtainable values in a regimented river:

Location of Lower Station	Av. Water Temp. at Kingston	Av. Water Temp. at Lower Stn.	Temp. Diff. between Air and Water	Dis:. in Miles to Kingston	Calculated Temp. in a Regimented River (Lake at 44°)
Kingston	40.5		12.0 (av.)	25 (up to lake)	43.8
Brockville	40.5	37.2	16.4	40	43.4
North Channel	41.6	38.7	8.9	64	43.6
Cardinal.........	38.9	33.8	11.4	67	43.45
Massena Point	39.0	33.6	11.0	103	43.25

In the calculations a loss rate of 100 B.T.U. per degree temperature difference per day was adopted and a stream velocity of two miles per hour. The drop in temperature between the deep lake and Kingston is not surprising for the river flows over vast areas of relatively shallow lake water. It is, however, something of a natural tragedy that of 12 degs. of sensible heat available in the deep lake against freezing, practically one-third of this amount should be lost by the time the waters reach Kingston, the distance to which is less than one-tenth of the distance from the deep lake to tidewater.

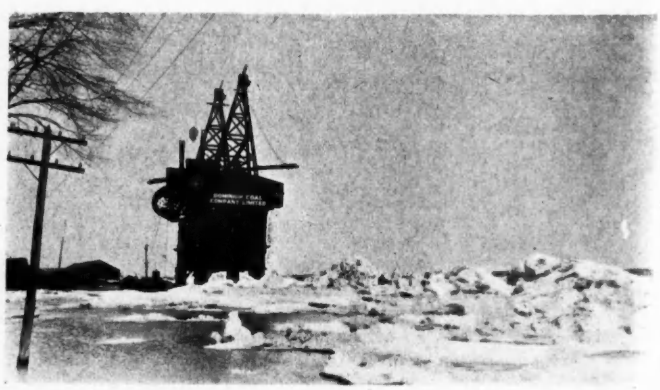
It is possible that the assumed figure of 44 degs. F. for the lake temperature is a little too high for the years 1924 and 1925 when the observations by the Joint Board of Engineers were made. The assumption, however, agrees with Mr. Millar's observations in later years.

In 1925 Dr. Barnes has recorded that the water temperature at the Victoria Bridge, Montreal, was 32 degs. F. on December 10th; making the same assumptions as above it would appear that the temperature loss between Lake Ontario and the Victoria Bridge should not exceed 1.5 deg. F. in the first week in December, provided that the waters were brought down in a regimented river flowing at a speed of about two miles per hour. The waters could be made to reach Montreal Harbour with a temperature well above 40 degs. F. in early December.

It should be noted that the temperature of Lake Ontario grows steadily lower as the winter proceeds and that it reaches its minimum in March. Fortunately, as Mr. Church's observations show, and as theory confirms, the rate of heat loss per sq. ft. of surface also grows less and less as the winter proceeds and as the sun gains in altitude until at some date in March the waters cease to lose heat and commence to grow warmer. The simultaneous falling off of heat supply in the lake and of heat demand from the flowing river is a most important fact for March lake water, if fed into the river in January, would not be warm enough to provide against the heat losses of the river in January. The writer having examined with some care the charts and topographical maps covering the area under discussion, has not detected any abnormal construction problems that would have to be dealt with in regimenting the St. Lawrence River to the measure required nor any for which precedent cannot be instanced.

Geophysical Laws

The study of the laws that control the heat cycles in the Great Lakes lies within the field of geophysics and has received a fair amount of attention, particularly by the staff of the Scripps Oceanographic Institute in California, which some fifteen odd years ago took up the problem of determining the rate of water evaporation from the surfaces of the many storage reservoirs scattered about in the State of California. Water evaporation in California and ice formation on the Great Lakes seem at first sight to have little relation to one another, but the forces that are active are the same in both cases and so are the controlling laws. The California study is well summarised by Prof. Burt Richardson in a paper presented to the American Society of Civil Engineers in 1930.[7]



Ice Invasion of Quay Surfaces

Briefly and disregarding minor causes, Professor Richardson limits the forces that act to raise the temperature of a sheet of open water to solar radiation and considers that only night radiation, evaporation and convection need be taken into account amongst the forces that act to reduce water temperatures.

The heat contribution of solar radiation, technically called insolation, at any point on the earth's surface can be calculated from

Ice Blockade of Canadian Ports—continued

the known constant of radiation for the sun, taking into account the sun's altitude at the time of observation and the losses of radiant heat that occur during the passage of the rays through the atmosphere. These losses are large and they are found, like nearly all geophysical factors, to vary largely and quickly with changes in the atmospheric conditions. Generally these losses aggregate

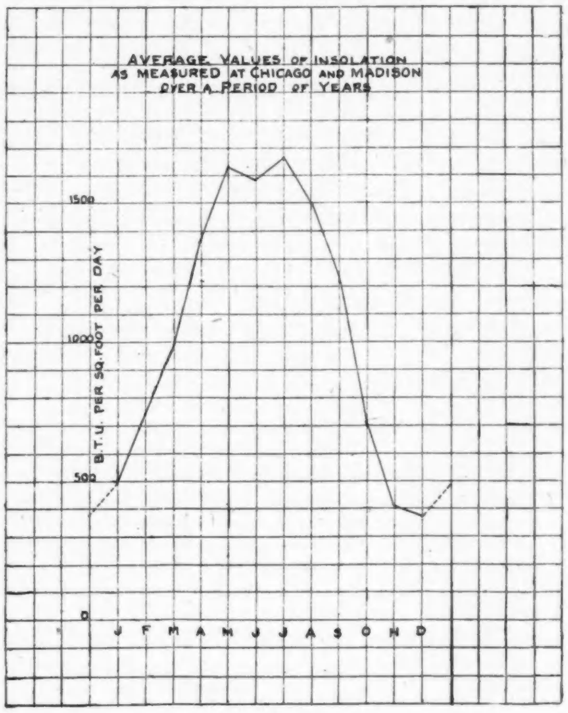


Fig. 7.

to more than 50 per cent. of the heat that would otherwise reach the earth's surface, so that in general it is more satisfactory to depend upon past records of the measurement of this factor rather than on scientific calculation. The United States Weather Bureau has several stations that regularly record the heat received on a flat surface from the sun and the Dominion Meteorological Service maintains one such station in Toronto. Fig. 7 shows the annual variations of insolation, the unit being B.T.U. per sq. ft. per day and the quantities are the means of observations made at Madison, Winsconsin, and at Chicago, Illinois. Insolation measurements are regularly reported in the *Monthly Weather Review* published by the U.S. Weather Bureau. The curve as shown on Fig. 7 is from the averages of two stations over many years and would be very much more irregular if only one year's observation at a single station had been used.

Measurements taken by Dean Birge and Associates at Madison show that practically all the radiant heat from the sun is absorbed in the upper 10-ft. of any pond. Subsequent distribution of such heat is principally the work of internal currents and is most active when the waters approach uniformity in density and temperature as they do in smaller ponds twice every year.

Black or night radiation is the radiation of heat from the surface of the earth into space. Because night radiation is a relatively long wave radiation it is very subject to atmospheric conditions, as will be seen from Fig. 8 which shows the results of a series of measurements of night radiation made at Fargo, North Dakota[8] for the U.S. Weather Bureau in 1937 and 1938. By use of the theory of least squares, a governing equation of

$$Q = 0.076 + 0.0006\ t$$

was obtained, where t is the air temperature in centigrade units and Q is in gram-calories per sq. centimeter per minute.

In theory the loss of heat by radiation varies as the fourth power of the absolute temperature of the radiating surface and Professor Richardson gives a formula for the calculation of this factor:

$$Q = c\ a\ T_w^4 - b\ a\ T_a^4$$

in which c and b are constants obtained from observations in California, T_w and T_a are the absolute temperatures of water and air, and *a* is the constant of black body radiation. Professor Richardson's formula has been used in the few calculations included in this paper. The equation is in centigrade units. The Dakota observations were not made from an open water surface.

In general the Dakota observations indicate that night radiation in the winter months is dominated by atmospheric conditions and is only slightly affected by temperature. Its value during the winter months seems to lie between 400 and 500 B.T.U. per sq. ft. per day and it may be considered to be approximately equal in amount to solar radiation during the months of November, December and January. In other words, the loss of heat from an open water surface during those critical months comes almost entirely from the factor of exaporation and from the closely connected factor of convection.

Probably the best known formula for the calculation of evaporation is the Meyer formula[9]:

$$E = 30\ (V - v)\ \ (.05 + 0.5w)$$

in which E is the evaporation in inches per month, V and v are the vapour pressures at the surface of the water and in the air passing over it and w is the wind in miles per hour.

Mr. F. E. Millar of the Dominion Meteorological Observatory has more recently advanced the following formula for the determination of evaporation losses, viz.:

$$E = \frac{1}{K_o^2} \qquad \frac{(e_w - e_a)\ u}{\log_e \frac{Z}{Z}\ \log_e \frac{Z}{Z'_o}}$$

in which

K = von Karman's constant = 0.38
E = No. of grams of water evaporated per sec. per sq. centimeter
e_a = No. of grams of water in the air per cubic centimeter at a height Z
e_s = No. of grams of water in saturated air of the same temperature as the open water
u = Speed of the wind in centimeters per sec. at the height Z

If the wind speed and specific humidity, i.e., u and e in the above formula, are observed at various heights and plotted against the logarithms of the heights of observation, it is an experimental fact

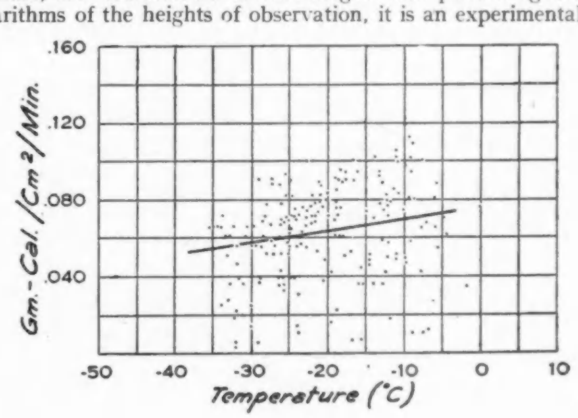


Fig. 8.

that the plotted observations will lie on almost straight lines intersecting the axis at heights of Z_o and Z_1°, respectively.

Practically these formulæ have been but little used, reliance being placed on direct observations of evaporation made from special test pans. However, it should be noted that both formulæ are governed by the factor $(e_w - e_a)$ denoting the difference of

Ice Blockade of Canadian Ports—continue

vapour pressure between air and water. In Fig. 9 a curve is drawn showing the relation between vapour pressure and temperature, the data being taken from the Meteorological Tables published by the Smithsonian Institute. It will be noted that vapour pressure does not vary directly with temperature and that therefore evaporation losses and the heat losses from open water that accompany them do not vary directly with temperature changes. Actually a drop of air temperature from 30 to 20 degs. F. will affect evaporation losses about five times as much as a corresponding drop from 0 deg. F. to 10 degs. below.

The actual losses due to evaporation from the surfaces of the Great Lakes are still a matter of controversy and the following figures are taken from two well-known estimates prepared respectively by Dr. J. R. Freeman[10] and by Lieut. H. C. Hickman of the U.S. Lakes Survey[6], the figures given being the evaporation losses in inches per month for Lake Huron:

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Freeman ...	3.4	3.2	3.0	2 5	1.8	1 0
Hickman ...	5.6	4.9	4.3	3.4	2.7	2.3

Considering the high standard of the two estimates the need of further series of observations is obvious, for evaporation will be the controlling factor in the net winter heat losses from the surface of the St. Lawrence waterway. In the rough calculations that follow, Lieut. Hickman's estimates have been adopted as being based on the most recent series of observational data. The conversion constant from water to water vapour is 970 B.T.U. per lb. of water evaporated.

The effect of wind upon the rate of evaporation still remains to some extent a matter of scientific dispute. Mr. Millar's experiments[11] made on a wind tunnel at the Dominion Meteorological Observatory show a direct variation in the rate of evaporation with variations in the difference of vapour pressure and also a direct variation with increase in wind velocity subject, however, to a correcting factor which itself varies with changes in the wind velocity. Lieut. Hickman's curves[6] show an increase of about 25 per cent. in the rate of evaporation at the usual air and water temperatures existing around Kingston during the months of December and January when the wind velocities are increased from 5 to 10 miles per hour.

Comparing the open river with the open lake it may be found by observation that evaporation from the open river will be greater in the winter months because the differences between the effective air and water temperatures will be found to be greater on the river than on the lake and also that the evaporation will be less from the open river because of a decreased effective wind velocity. Only a systematic meterological survey can supply the necessary data to determine these points.

TABLE III

Calculated Rate (mean) of Heat Loss in B.T.U. per sq. ft. per day as determined from the data listed above:

	December	January	February	March
Night radiation ...	619	568	464	247
Evaporation ...	648	585	507	355
Convection... ...	485	535	392	66
Sub-total ...	1752	1688	1363	666
Solar radiation ...	376	486	730	990
Net loss	1376	1202	633	—

Convection or the carrying away of heat by the air passing over an open water surface takes place at the same time as evaporation and it has been shown mathematically by Dr. Bowen that the heat loss due to convection is directly proportional to the heat loss due to evaporation (at least under California conditions), the connecting formula, known as Bowen Ratio, being

$$R = 0.46 \times \frac{P}{760} \times \frac{(T_w - T_a)}{(E_w - E_a)}$$

The formula is in metric units, P being the height of the barometer, T_w and T_a the temperatures of water and air and E_w and E_a the water content of the air in contact with the water and of the air passing above it in grams per cu. cm. It is not known whether Bowen's ratio will hold accurately under the weather conditions existing in the Great Lakes basin and in the St. Lawrence valley but it has been used in preparing certain figures that appear later in this paper.

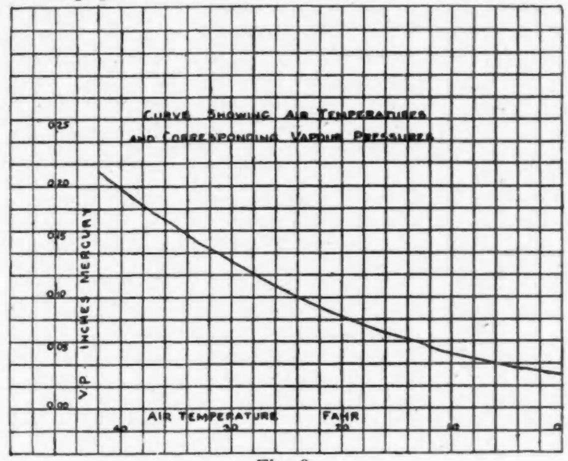


Fig. 9.

For the purpose of roughly checking by theory the figures in Table I obtained by calculation from Mr. Church's recorded observations, the writer has used the long-time average air temperatures of Wisconsin as published by the Wisconsin Academy of Sciences, Arts and Letters, Mr. Church's observations of water temperatures and Lieut. Hickman's estimates of water evaporation from the Lakes Huron and Michigan. The figures (Table III) are intended to be used only as an illustration.

If these figures are compared with those shown in Table I, they will be seen to indicate a close agreement if it be recollected that all the factors entering into the calculation are tremendously variable not only from one year to the next, but in some cases from one minute to the next, all depending upon atmospheric conditions.

Conclusions

It is obvious that the profession has need of masses of observational data to be taken in the Great Lakes basin and in the St. Lawrence valley in order to determine dependable average values for insolation, night radiation, evaporation and convection. So large a statistical task lies properly in the field of the great governmental bureaux of the United States and Canada.

Tentatively at least the following conclusions may be drawn from the foregoing discussion:

1. The Great Lakes are great natural accumulators of heat energy.
2. The temperature of the mass of their waters is never as low as freezing point.
3. The temperature of the deeper waters is never lower than that of the surface waters concerning which a considerable mass of statistical data has already been secured.
4. The date of cooling off of the water under St. Lawrence Valley conditions has been in some measure determined.

There remains for the profession the two main problems of:

1. Designing outlets to the lakes so that only the "warm" waters of the lakes will be drawn into the outflowing rivers.
2. To regiment the channels of the outflowing rivers so that the loss of heat from their surfaces will be reduced to a minimum.

To the writer the following local problems appear to be worthy of professional study and consideration if the heat energy contained in the waters of the Great Lakes is to be put to beneficial use, viz.:

The location of the principal ice-forming areas in the Great Lakes.

The devising of ways and means to confine sheet ice to its place of formation and to the limit as far as possible the movement of float ice when drifting under the influence of current and wind.

The designing of detour channels around the principal gathering areas of drift ice, such as Whitefish Bay and the south end of Lake Huron.

(concluded on page 318)

Port Operation

Part 2 (C) of a series of articles by A. H. J. BOWN, M.Inst.T., A.C.I.S.
and Lt.-Col. C. A. DOVE, M.B.E., M.Inst.T.

(Continued from page 285)

Organisation *(continued)*

Docks' Railways

By now the student will have grown used to being warned of the differences in organisation between ports and should not, therefore, be surprised to learn that they are to be found in the same full measure in the operation of docks railways.

As would be expected, all dock owning railway undertakings operate their own dock railways, as, in fact, do many other port authorities, but this system is far from universal. In the Ports of London and Calcutta all trains, both in and out, are exchanged with the main line railway companies at the exchange sidings situated in the port undertakings' area. In both these cases, the port authority provides the engine power and the staff necessary to operate the railway in their own areas. At Leith, however, which is served by two railway companies, the docks railway is operated for the Commissioners under an arrangement with the London & North Eastern Railway Company, who pay the Commissioners for the use of the rails. The railway company also provide all the locomotives and shunting engines. As has already been mentioned, the railway company goes still further by providing all the capstanmen on the quays. A similar situation exists at Glasgow, where the dock railway is run by the London, Midland & Scottish Railway Company. Needless to say, the Manchester Ship Canal Company operate and own their own docks railway.

Whether the work is farmed out or otherwise, the Railway Department is usually a section of the Traffic Department (although it operates under different names, e.g., in Calcutta it is known as the Transportation Department, in London as the Railway Department). But even this practice is not universal, for in Bombay, which has a large Docks Railway organisation, the Railway Department and the Docks Department are operated under two separate departmental chiefs known as the Railway Manager and the Docks Manager respectively, each of whom reports direct to the Chairman, although during the 1939-45 War a General Manager was appointed, one of whose duties was to control both of these departments. It is interesting to note that a comparable situation exists in the port of Alexandria, where both the railways and the docks are State owned, although under two separate Government Departments, in that the railways are operated in the docks area by the State Railways Department and not by the Ports and Lights Administration, who are the port authority.

Although the Docks Railway Organisation is part of the Traffic Department in most ports, it is usual for it to be organised as a separate section within the Department under an official, known in various ports by different titles, including Railway Operating Superintendent, Transportation Superintendent and Railway Superintendent, who comes directly under the Traffic Manager.

The Railway Operating Superintendent is responsible to the Traffic Manager for (1) all railway operating on the port undertaking's estate, (2) co-operating with the main line railway companies, (3) maintaining contact with other departmental or sectional heads, particularly Dock Superintendents, (4) rendering and passing for payment all accounts relating to docks railway operating, (5) organising and paying the railway operatives employed by the port undertaking. He is not responsible in most ports for (a) repairing, renewing or maintaining locomotives, rolling stock and signal apparatus or (b) repairing, maintaining or renewing the permanent way. These functions are normally the responsibility of the Mechanical Engineer (a) and the Civil Engineer (b) respectively.

Discharging deck cargo of timber by hand. Shore gang (timber porters) on shore, and stevedores on ship. (Part 2 (B) refers).

To help him in the execution of his duties, depending upon the size and layout of the port, the Railway Operating Superintendent has the services of one or more Assistants. In a port like London, where the various dock systems are widely scattered, it is usual for the areas controlled by the Railway Operating Superintendent to be divided into a number of regions, each capable of being administered and operated as a self contained unit, corresponding in location and area covered to those administered by the Dock Superintendents. Each region is controlled by an assistant designated as Yardmaster, Railway Inspector, Railway Controller or Railway Traffic Officer. In other ports, where the docks and wharves are not so spread out, the Railway Operating Superintendent, whose own office is usually located near the Traffic Manager's, is assisted by an officer who acts as his second in command and chief executive, stationed at an office on the docks estate near the exchange sidings. In Calcutta, where an arrangement similar to this is in force, he is known as the Transportation Superintendent.

The assistant described above (Yardmaster) is responsible to the Railway Operating Superintendent for ensuring that the following functions are satisfactorily carried out:—(1) taking over

Port Operation—*continued*

trains from or handing over trains to the main line railway companies at the reception or exchange sidings; (2) examining all railway wagons at the exchange sidings, both before accepting them from or offering them to the main line railway companies; (3) recording the numbers of all trains and railway wagons on arrival at or departure from the exchange sidings; (4) sorting, marshalling and shunting operations; (5) signalling; (6) lighting; (7) working level crossings; (8) placing and drawing off of railway wagons punctually on and from quays as required by the dock operating staff; (9) ensuring that sealing, where necessary, and labelling have been satisfactorily completed before the train is taken over; (10) that all work performed has been charged for in accordance with the laid down schedule of charges; (11) rostering the operating staff, e.g., locomotive drivers, firemen, shunters, signalmen, wagon examiners, cleaners, crossing keepers, capstanmen, number takers and checkers. (It should be noted that practically throughout the world, dock railway systems are operated on a 24 hour basis, which necessitates shift working by the operatives, whereas all the other labour employed on ship and shore work operates on a day basis only. The length of a " day " varies from country to country, but roughly it is equivalent to the daylight hours available. A considerable amount of work takes place outside these hours, of course, but it is regarded as overtime and does not normally entail the rostering of the workpeople as a day to day practice).

Rebagging nuts discharged to lighter, showing needlemen (stitchers) backs to camera, rebagging gang, weighers (foreground), twine for sewing (on scales), 1 set being hoisted ashore and 1 set made up ready for hoisting (left foreground). (Part 2 (B) refers).

It should be noted that the Yardmaster has no responsibility for shunting engines once they are in the locomotive running sheds, where they come under the control of the Mechanical Engineer.

The number of Assistant Yardmasters necessarily depends on the size and layout of the areas controlled by the Yardmaster. Usually there is one whose job it is to understudy the Yardmaster. He is normally also given some specific responsibilities such as administration, payment of the workpeople, and preparation of the daily rosters.

The direct control and supervision of the work is vested in foremen, whose titles and duties are in the main dictated by the functions of the yards they control and the duties they perform. In most rail connected ports, the working arrangements and layouts are similar. Trains coming into the port are taken over from the main line railway companies at the exchange or reception sidings, where they are checked, broken down according to the berths or warehouses for which they are destined and shunted by the port undertaking's locomotives to the sorting sidings. From the sorting sidings they are hauled by the port authority's shunting engines to their destinations. In the case of wagons loaded with cargo for export, after off-loading they are drawn off and, if there is cargo on offer, placed at import berths or warehouses for loading after they have been cleaned, if this is necessary. After loading, the process works in reverse, the wagons are drawn off the quays, marshalled into trains in the marshalling yards in accordance with their destinations and handed over to the main line companies at the exchange sidings. (In railway owned ports, the exchange is between the main line organisation and the dock organisation.)

Each of these yards or nests of sidings has a foreman or assistant foreman in charge, who normally operates under a senior operative known as the Chief Yard Foreman or Yard Foreman, according to the scope of his duties. It is customary in most ports to have a foreman shunter.

It is to be noted that in the Port of Liverpool the organisation described above does not apply. The Mersey Docks and Harbour Board do not provide exchange sidings. Their place is taken by railway stations operated by the railway companies which serve the port. The Board, however, provide the locomotives which haul the waggons between the railway stations and the dock quays. An interesting difference between import and export practice takes place on the dock quays where import cargo is loaded to railway waggons by labour employed by the master porters, but export cargo is struck by the shipowner's labour.

Dockmaster's Section

The Dockmaster's Department or Section is usually made responsible for the execution of the port undertaking's statutory duties in connection with the control of ships and craft within dock waters, including, according to the custom of the port, such operations as locking in and out, dry docking, mooring, unmooring and moving ships. As will be shown later, a fundamental difference between systems is to be found in the allocation of the Dockmaster's Section either to the Traffic Manager's Department or to the River Conservator, as is illustrated by reference to London and Calcutta.

Canteens

An important war-time development which appears likely to become a permanent feature of port organisation is the provision, staffing, victualling and management of dock canteens for workers by port undertakings. It is mentioned here because in some ports, e.g., London, it is a function controlled by the Traffic Organisation. In London the responsible official (Catering Officer) comes under the Commercial Superintendent. This arrangement is not universal, however, for in Bristol, to cite but one variation, it is a responsibility which is discharged by a member of the Secretary's staff (Canteen Manager).

River Conservator or Harbour Master's Department

In those ports where the statutory port authority also fulfils the functions of a River Conservancy, a separate department almost invariably exists to carry them out. It may pass under one of several titles, e.g., Conservator's Department, Harbour Master's Department or River Department. Normally, it covers many responsibilities, although, as will be shown, practice varies from port to port, and not infrequently certain of them are performed by

TRAFFIC DEPARTMENT, PORT SUDAN.

PORT MANAGER

- Asst. Port Manager
  - Asst. Port Manager
    - Chief Warehouse Inspector
      - Asst. Chief Warehouse Inspector
        - Import Section
        - Export Section
        - Labour
    - Shore Supervisor*
      - Asst. Shore Supervisor
        - Main Quays (East Side)
          - Quay Masters
            - Quay Foreman
        - South Quays
          - Quay Masters
            - Quay Foreman
    - Operations Inspector
      - Traffic Inspector
        - Main Quays (East) and Warehousing Area
        - North Station (all functions
        - Port Sudan Town Station (all functions)
        - South Quays
        - Control Office (Railway)
        - Railway Telegraph Offices
        - Port Telephone Exchange
        - Shunting Power and Shunters
        - Wagon Supply and arranging of trains
- Chief Clerk
  - Senior Clerk
    - Commercial Section
    - Staff Section
    - Agency Section (Clearing & Forwarding, Govt. Cargoes)
    - General Section
    - Marine Clerk
- Harbour Master
  - Asst. Harbour Master
    - Pilotage Service
      - Chief Pilot
        - Pilots
    - Tugs
      - Senior Tug Master
        - Deck Crews
    - Berthing Master
      - Asst. Berthing Master
        - Berthing Parties (sailors)
    - Pontoons Launches and small craft
      - Deck Crews

* Inboard work carried out by Shipowners' Agents

GREAT WESTERN RAILWAY

ORGANISATION OF DOCKS DEPARTMENT AND RELATIONSHIP WITH ENGINEERING DEPARTMENTS

GENERAL MANAGER

- Traffic and Passenger Dept.
- Goods Dept.
- Docks Dept.
  - Chief Docks Manager
    - Assistants
      - Docks Manager Cardiff and Penarth
      - Docks Manager Swansea
      - Docks Manager Newport
      - Docks Manager Barry
      - Docks Manager Port Talbot
      - Dock Manager Plymouth
        - Each Dock System
          - Marine (Dock Master)
            - All ship movements including locking
          - Docks Traffic
            - All movement of Railway Traffic from receipt at Main Line Junctions or *vice versa* including all working inside Docks line of demarcation
          - General Cargo
            - All loading and discharging operations except coal including sheds and stevedoring
          - Coal Shipping
            - All coal shipment or any other traffic dealt with at coal hoists
          - Dock Accounts
            - All traders' a/cs and returns, documents, vouchers etc., necessary to place the Chief Accountant in a position to produce final Account, Balance Sheets, etc.
    - Ship Management Section (Marine)
      - Supt. (Marine)
      - Supt. (Engr.)
- Chief Engineer (Civil)
- Chief Mech. Engineer
  - Resident representatives of Chief Engineer and Mechanical Engineer
    - Responsible direct to respective Chiefs for all maintenance, new works etc., but Docks Managers are commercially responsible through C.D.M.
- Chief Accountant
- Others such as Sec y's, Hotels' Stores, etc.

RANGOON

ORGANISATION OF TRAFFIC AND MECHANICAL DEPARTMENTS

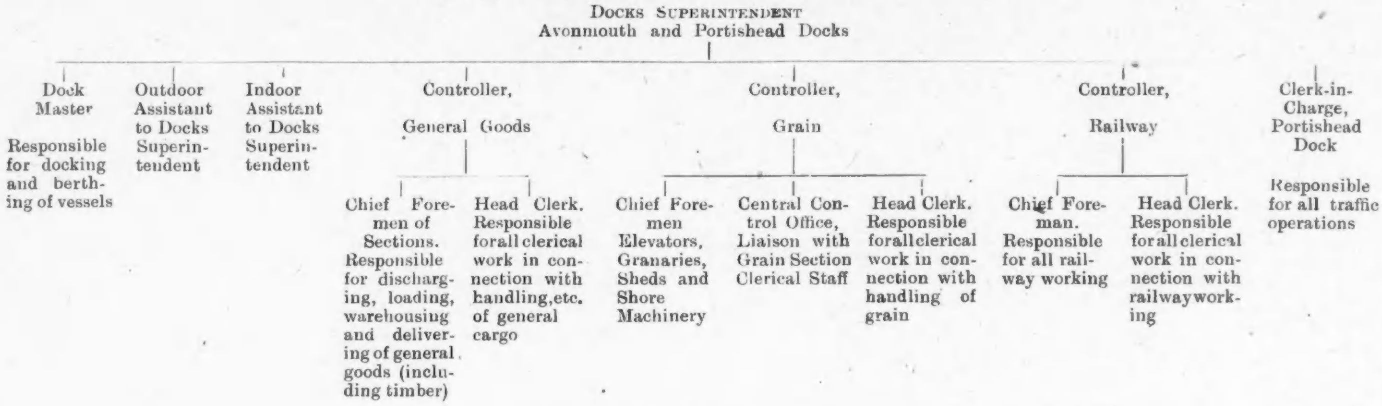
TRAFFIC MANAGER — **CHIEF MECHANICAL SUPERINTENDENT**

- Asst. Traffic Manager
  - Supt. Wharves (2)
    - Asst. Supts. (3) (Ahlone)*
      - Checkers (12)
    - Asst. Supts. (6) (Lanmadaw)*
      - Checkers (12)
    - Asst. Supts. (6) (S.P.W.)*
      - Checkers (72)
    - Asst. Supts. (3) (B.S.W.)*
      - Checkers (24)
- Asst. Traffic Manager (Labour and Welfare Officer)
  - Supt. Adjt. (1)
  - Supt. Q. (1)
    - Supt. Stevedore Labour
      - Supervisors (12)
        - Ship Overseers (2 per ship)
          - Gang Maistries (1 per gang)
            - Labourers 130 gangs of 14 men 20 gangs of 19 men
    - Supt. Shore Labour
      - Asst. Supts. (3)
        - Gunners (80)
          - Gang Maistries (1 per gang)
            - Labourers (335 gangs of 14 men)
- Asst. Mech. Superintendent (I/c Mechanical Plant and Gear)
  - Mech. Foremen (4)
    - Fitters
      - Crane and Lister Truck Drivers
  - Foremen (3)
    - Riggers (15)

* Ahlone—Ahlone Wharf
* Lanmadaw—Lanmadaw Wharf
* S.P.W.—Shwedagon Pagoda Wharf
* B.S.W.—Butlin Street Wharf

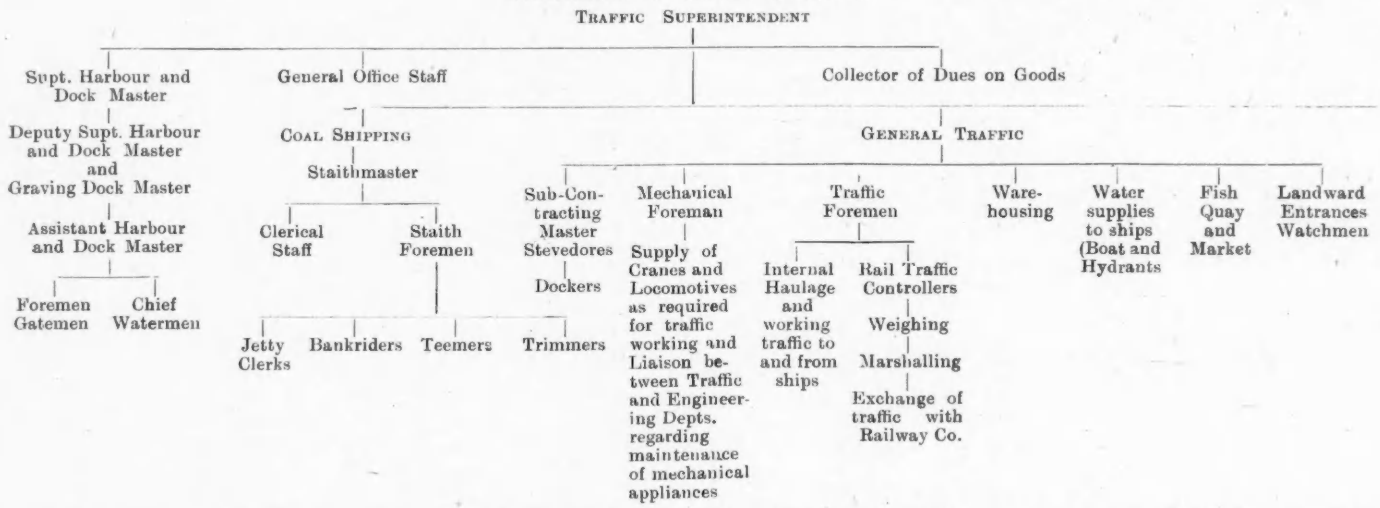
Port Operation—continued

BRISTOL : ORGANISATION OF DOCK SUPERINTENDENT'S DEPARTMENT



RIVER WEAR COMMISSIONERS

ORGANISATION OF TRAFFIC DEPARTMENT



other departments or authorities. They include the provision and maintenance of approach channels, dredging, lighting and buoying, wreck raising or dispersal, salvage, supervision of foreshore and prevention of erosion, berthing of vessels, manning and maintenance of lock entrances, taking over vessels from pilots and navigating to operating berths and hydrographic survey.

It is not unusual for the department to be sub-divided into sections, such as dredging, salvage, harbour master's, survey, dock master's, according to the professional duties involved.

Dredging, both in the river and the docks or harbour, is usually the responsibility of a specialist officer of the Conservator's Department, although at some ports—Bristol and Glasgow, to name but two—it is a responsibility of the Engineer's Department. Many port undertakings own dredgers and employ crews to operate them, others put dredging out to contract.

The marking, buoying, lighting, salvaging and dispersal of wrecks or other obstructions are duties placed on most port authorities under their Act. Other lighting and buoying is frequently the responsibility of the Conservancy Authority, although London provides an exception. On the Thames, lighting and buoying, except wreck marking, devolves upon the Pilotage Authority, i.e., The Corporation of Trinity House of Deptford Strond, usually known as Trinity House, and not upon the Conservancy Authority (Port of London Authority).

Most ports have a Hydrographer or River Surveyor, as he is more usually called, who charts and records river, harbour and dock depths and tidal tendencies. The necessity for such a survey is always present, particularly in ports where approach depths have been artificially produced. The frequency of the survey depends on local conditions and one cannot do better than refer to the notoriously difficult Hooghly, which has ten major bars between Calcutta and the sea, some of which become mere crossings at certain seasons, but all of them fluctuate, shoaling or deepening at times by as much as three or four feet in a tide. The accuracy of this survey may be judged from the fact that ships are piloted with a margin of safety between the ship's bottom and the mud or sand of the shallowest bar, of only 18 inches on a falling tide and from six inches on a rising one. It is extremely important to note that it is not sufficient for the survey to be efficient and up to date, but it must also be passed without delay to the Pilotage Service, which, although relying absolutely on the day to day accuracy of the survey work, rarely belongs to the same organisation as the Survey Service. In Calcutta, for example, the Pilotage Authority is the Bengal Pilotage Service, which is under the Department of Transport of the Central Government of India, but the survey is conducted by the Deputy Conservator's Department of the Calcutta Port Commissioners.

The maintenance of foreshores is in general the responsibility of the occupiers of the land, but nevertheless it is necessary for the Conservancy Authority to exercise constant vigilance, and in an emergency to take action where a sudden or serious erosion is likely to prove a danger to shipping or impair access to the port.

In some ports, such as Glasgow, the Pilotage Service brings vessels right on to their moorings or alongside their berths, in which case the Harbour Master's Department may merely be responsible for ensuring that the operations of mooring and unmooring are satisfactorily executed. But in other ports, Calcutta for example, the vessel is handed over to the port authority before

Port Operation—*continued*

the ship is berthed, in which case the Harbour Master's Department takes over. In some ports all the port undertaking's work in connection with the handling of ships is controlled by the Harbour Master's Department, but in others, part of this work comes under the Traffic Department. The difference in practice may best be illustrated by comparing Calcutta with London.

In Calcutta, the Hooghly Pilot hands the vessel over to the Harbour Master's Department, which is a section of the Deputy Conservator's Department of the Port Commissioners, at Garden Reach, a point in the River Hooghly roughlv half a mile from the nearest dock entrance or river berth. The Port Commissioners are represented by an Assistant Harbour Master, who either (a) pilots the vessel to a river berth or mooring, in which case he remains on board until the vessel is berthed, or else (b) pilots her to the entrance lock to the wet docks, and then either continues with her to her dock berth or else hands her over to a Berthing Master, also a member of the Harbour Master's Department, who takes her on to her berth. It must be stressed, however, that from the time the vessel is taken over until she is berthed, including her passage through the entrance locks, the Port Commissioner's duties are carried out by officers who are responsible to the Deputy Conservator and not the Traffic Manager.

In London, however, the Port Authority undertake no part of the piloting, which is carried out by Trinity House pilots as far as the outer sill of the entrance lock. The vessel then comes under the control of the port authority, who provide an employee, usually an assistant dockmaster, to control the passage of the vessel through the entrance lock and supervise the work of the lockmen, who are employed by the port authority to take the vessel's lines whilst she proceeds through the lock under her own power. This staff belongs to the Dockmaster's Department, which is a part of the Traffic Organisation and not the Harbour Master's Department.

Pilotage is not compulsory in the docks in London and once the vessel is through the entrance lock she comes under the control of her own officers. Many shipping companies, however, make use of the services of dock pilots in dock waters. These dock pilots are not employees of the port authority and their services are the subject of private arrangements between themselves and the shipping companies.

The responsibility for coming alongside dock berths and tying up devolves upon the ship and not the port authority, who provide no staff for this purpose. Most shipping companies employ special men for mooring and unmooring.

As has already been explained, the duties normally ascribed to a Traffic Department are carried out in London in the General Manager's Department by one or other of his assistants. In effect, as far as the Port of London Authority is concerned, the Harbour Master's Department is responsible for the ship whilst she is riverwards of the lock entrance and the General Manager's Traffic Organisation whilst she is in the entrance lock or dock.

It may be taken for granted that at no port would a Harbour Master or Dock Master be over-ridden by a non-technical officer of the port undertaking if it involved taking a navigational or marine risk.

Estate Department

Most port authorities have an Estate Department which, in addition to negotiating leases, lettings and sales, and dealing with valuation and rating questions, also obtains options or acquires land which may be required for future port development. Sometimes the policy of the port includes the purchase of land in the vicinity of the port for the purpose of setting up and developing industries which will help to stabilise the trade of the port.

It has long been the practice in India to provide a certain number of dwellings near the port for housing dock labourers and their families, but now much larger schemes allowing for many more dwellings and embracing welfare facilities, such as hospitals, are in contemplation. It is hoped in this way not only to improve the lot of the labourers, but to change the status of the seasonal workers, who leave their families in up-country villages whilst they are working in the docks, by providing them with permanent homes and thereby inducing more of them to become regular dock workers all the year round.

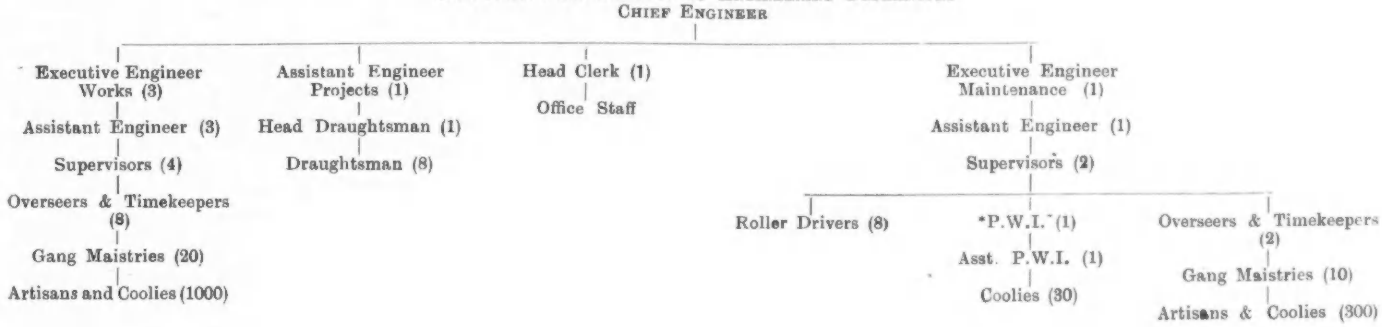
Engineering Department

The engineering duties carried out in a port authority are normally classified under three heads: (a) Civil, (b) Mechanical, (c) Electrical. In some ports, as in London and Bristol, for example, a Chief Engineer is appointed with assistants to cover each department. The following table of the organisation at Bristol shows this method very clearly.

At other ports a Chief Engineer deals with all civil engineering matters, and a Chief Mechanical Engineer with an electrical assistant controls the Mechanical and Electrical sides.

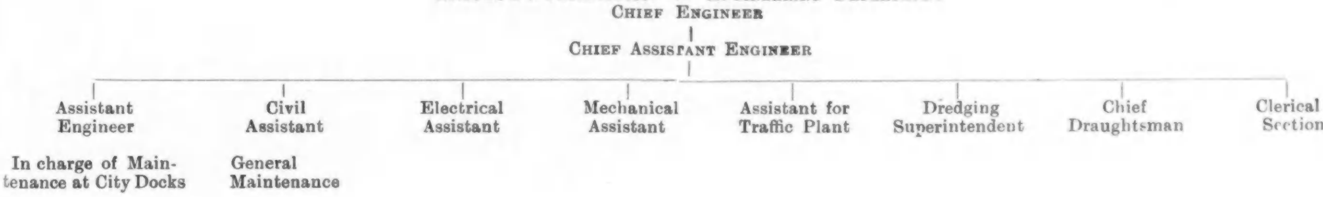
It is important that all students actively engaged in port operating should have a sound appreciation of the duties of the engineering departments in his own undertaking, for on their care and maintenance and advice on such matters as lay-out, running costs, methods of traction, selection of cranes and cargo handling gear, depends much of the success of the Docks Operating Department. Speaking broadly, the civil side deals with all static installations, including such matters as dock construction, maintenance, lay-out and permanent way, and the mechanical side all moving objects, such as cranes, runabouts, pilers and locomotives.

RANGOON : ORGANISATION OF ENGINEERING DEPARTMENT



* Permanent Way Inspector

BRISTOL : ORGANISATION OF ENGINEERING DEPARTMENT



Port Operation—continued

Pilotage

In most ports throughout the world, pilots are available for bringing ships into port from the open sea or working in the reverse direction. In some ports, vessels in excess of a certain tonnage are not allowed to enter without pilots, such ports are known as "Compulsory Ports," whilst those which do not insist on the use of pilots are known as "Non Compulsory Ports."

The body responsible for the organisation and recruitment of the pilot service and for the scale of charges imposed is known as the Pilotage Authority, although it is interesting to note that Pilotage Authorities often depute some other authority to collect charges on their behalf. In Calcutta, for example, the collection of Pilotage Dues from shipping is undertaken by the Port Commissioners, and in London the dues on certain foreign compulsory pilotage vessels are collected by the Chief Officer of Customs.

Sometimes, as in the case of Liverpool and Bristol, the Port Authority is also constituted the Pilotage Authority. In other cases, as for example London (Trinity House), Hull (Humber Conservancy Board), pilotage is vested in an autonomous body other than the port authority. On the Firth of Forth, both systems operate side by side, with the result that there are no less than six separate pilotage organisations on this comparatively short stretch of water, i.e. (1) Bo'ness; (2) Methil and (3) Burntisland (all L. & N.E. Rly. Co.); (4) Trinity House of Leith; (5) Grangemouth (L.M.S. Rly. Co.); and (6) Kirkcaldy Town Council. On the Hooghly (Calcutta) yet another system is in force, for there the Bengal Pilotage Service operates, as has already been mentioned. as a part of the Transport Department of the Government of India.

Trinity House is by far the largest pilotage authority in this country. It should be noted in passing that Trinity House is also the general lighthouse authority for England, the Channel Islands and Gibraltar. Although Scotland and Northern Ireland have their own commissions, any additions or alterations in lighting or marking require the approval of Trinity House.

Pilots are normally recruited from Merchant Marine officers, who serve what is tantamount to a period of apprenticeship with the Pilotage Authority before becoming fully fledged pilots. Even then they are graded and usually work their way up from shallow drafted vessels to those drawing the maximum depths allowed.

The methods of selecting and organising pilots differ from port to port, but brief explanations of the systems used at Calcutta and London illustrate the care which is used.

The Head of the Pilot Service in Calcutta is the Port Officer (Pilotage), generally a pilot of some 30 years' experience with the Pilotage Service, who is directly answerable to the Transport Member in Delhi. His responsibilities include organising the pilotage service and deciding the drafts at which ships may be brought up and to which they may be loaded, having regard to the rise of tide and the depth of water on the bars from day to day. He arranges the supply of pilots to ships in Calcutta and at the mouth of the river from the Pilot vessel. The length of Hooghly over which the Pilotage Service operates is about 125 miles and this necessitates the stationing of a vessel at the mouth of the river on which the Pilots can live between leaving an outgoing vessel and boarding an incoming one. The transference of pilots to and from the Pilot vessel is known as "boating."

A candidate for the Bengal Pilot Service must hold a 2nd mate's Board of Trade Certificate. If he is accepted, he enters as a "Leadsman" apprentice.

At the end of two years' service, he becomes a 2nd Mate Leadsman, subject to passing an examination. Two years later he may qualify as a 1st Mate Leadsman, again by examination. Another examination is held at the end of the fifth year, success at which qualifies him as a Mate Pilot.

A Leadsman does not pilot ships. His job is to heave the lead on bars whenever his pilot wants soundings taken. During his five years of training, he serves as an officer of the Pilot vessel for part of the time and "runs" on the river, with pilots who teach him his job for the balance.

Mate Pilots are divided into two classes: Junior Mates, who are the lowest grade of pilots, and Senior Mates, who are pilots of from 7 to 10 years' standing. They are not allowed to pilot ships of greater draught than 25-ft. 6-in. and normally do not pilot ships of more than 4,500 tons gross.

A Mate Pilot has one more examination to pass before he becomes a Master Pilot, at which stage he may have from 10 to 20 years' service behind him and is normally limited to ships of between 4,500 and 6,500 tons gross.

Next in the hierarchy come the Branch Pilots, who are qualified to take the largest vessels using the port. In addition, they are qualified to act as Marine advisers on Courts of Enquiry, where questions of navigation of the Hooghly arise, and to sit on examination boards for the promotion of junior pilots.

The Senior Branch Pilot acts as the Deputy to the Port Officer (Pilotage).

Trinity House Pilot based on Gravesend, River Thames, boarding a ship from the Pilot cutter.

Ships coming into London pass through two compulsory pilotage areas: (1) the South Channel and North Channel, commencing at Dungeness and Orfordness respectively, and (2) the Thames from Gravesend to London Bridge. In both cases, The Corporation of Trinity House of Deptford Strond (Trinity House) is the Pilotage Authority and issues the licences.

Qualifications for the two areas vary in some respects, but in both cases the candidate must have a Board of Trade Master's Certificate for a foreign going steamship, have served seven years at sea or on the Thames below London Bridge, and have had not less than one year's service as a first mate in a steam ship of 700 tons or over, trading in the district for which he is applying. A candidate for a licence for the channel areas must have, in addition, at least one year's service as a second mate, or above, of a square-rigged sailing ship of not less than 150 tons.

Licences are also granted to certain applicants who have spent many years navigating vessels on the Thames, who are known as "Exempt River Pilots."

Having satisfied these requirements, both types of candidates must then pass an examination in marine matters and, if successful, (1) in the case of Channel Pilots, take twelve voyages at their own expense with a licenced pilot, or (2) in the case of pilots for the River Thames area, spend three months on probation at their own expense with the Ruler of Pilots.

Many of the Pilotage Authorities in this country have their roots in the distant past and, generally speaking, are much older than the Port Authorities through whose areas they operate. The legislation controlling them, however, was brought up to date by the Pilotage Act, which was passed in 1913 with the object of consolidating and amending the law relating to pilotage.

(To be continued).

Additional Reading as for Part 2 (B).
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Notes of the Month

New Wharf at Port Darwin.

A new wharf, 605-ft. long and 140-ft. wide, is to be built at Port Darwin instead of the shorter wharf previously approved. With the provision of cranes and handling facilities, the improvements are expected to cost approximately £420,000.

Expansion of Norwegian Shipyards.

It is reported from Oslo that the Norwegian Government intends to guarantee loans of £1,500,000 to seven Norwegian shipyards for modernisation and expansion. It is estimated that, at the end of two or three years, annual shipbuilding capacity of these seven yards will have increased from 50,000 to 135,000 gross tons and will equal that in Sweden and Denmark. Norway formerly was the largest shipbuilding country in Scandinavia, but with the advent of larger Diesel-driven vessels, Norwegian shipowners found it necessary to order their ships abroad. It is this situation the Norwegian Government is seeking to remedy.

Medway Wreck Menace.

In the House of Commons recently, the Parliamentary Secretary to the Admiralty was asked whether he was aware of the problem in regard to navigation caused by the presence of the wreck of H.M.S. *Bulwark* in the Medway; that the situation was steadily growing worse by siltation and if his department would take the necessary steps to remove this 25-year-old menace to shipping at an early date. In reply, Mr. W. J. Edwards, Civil Lord, said that he was not aware that any difficulties were caused to shipping and he was advised that it was not practicable to remove the wreck. He agreed to meet a deputation of those concerned, to discuss the matter.

General Council of British Shipping.

At the annual meeting of the General Council of British Shipping which was held at Bury Court, St. Mary Axe, on the 20th ult, the following appointments for 1947-8 were made:—Chairman, Sir Ernest Murrant, K.C.M.G., M.B.E.; Joint Vice-Chairmen, Sir George Christopher (London) and Mr. J. B. Watson Hughes (Liverpool). The General Council was formed in 1941 to negotiate with the Government on matters of policy of major importance to the shipping industry. On the Council are represented the Chamber of Shipping of the United Kingdom and the Liverpool Steam Ship Owners' Association.

Port of Stockholm Development Plans.

According to a recent article in the *Svenska Dagbladet*, the enlarging of the Port of Stockholm has become an urgent necessity, and the final development of the city will include the construction of a further 8,000 metres of quays laid out with railway lines and equipped with cranes and warehouses, at a cost of about 100,000,000 kroner. A valuable extension to the town quayside is at present being provided by the enlargement of Masthamnen, at Tegelvikena, which is being made 550 metres long and about 100 metres wide. These extensions have been accompanied by considerable difficulties of construction. One part of the quay will be in use within the next 12 months, and it is hoped that the work will be completely finished by the end of next year.

Navigation of the River Dee.

A conference, representative of local authorities in Flintshire, Cheshire and Denbighshire, met at Connah's Quay early last month to explore the possibilities of improving the navigation of the River Dee from Chester to the sea. It was stated that the river had gradually deteriorated over many years and that its present condition was due to silting up by the tides, which had been uncontrolled for a long period. If something could be done to improve the river it would mean the revival of the Deeside ports and attract new industries to Flintshire. A committee was formed comprising all the delegates present and it was decided to ask the River Dee Catchment Board to receive a deputation and later to approach the Flintshire County Council on the matter.

New Shanghai Dockyard.

Plans are being drawn up for the construction in Shanghai of the largest dockyard in China, which will be capable of building vessels up to 30,000 tons. The equipment for the new dockyard, to be completed within three years, will be drawn mainly from the 50,000 tons of Japanese reparations to China, of which a large part consists of shipbuilding machinery. At present the Kiangnan Dockyard, controlled by the Chinese Navy, is the largest in China.

Tribute to Lifeboat Crew.

Capt. J. Rasmussen, master of the motorship Bolivar, which went aground on the Kish Bank on March 4th, has left Dublin and returned to Norway. Before his departure, he paid tribute, on behalf of all in the Bolivar, to the crew of the lifeboat which rescued the passengers and crew, stating that their coolness, dexterity and courage was equal to anything he had ever seen, and had aroused the admiration of all concerned. He would report their splendid achievement to the owners of the ship, Messrs. Fred Olsen & Company, in Norway.

Dunseverick Harbour Improvements.

The Parliamentary Secretary to the Ministry of Commerce recently stated in the Ulster Parliament that the delay in the carrying out of improvements at Dunseverick Harbour was due to the fact that the Antrim County Council, the owners of the harbour, would not accept a recoupment by the Government of 50 per cent. of the cost of a new breakwater estimated at £3,400. The scheme had been agreed to in detail, but the Council wishes the grant to be 75 per cent. He was unable to hold out any hope of increased financial assistance from Government funds.

Salvage Operations at Narvik.

Twenty ships sunk during the war are still lying in Narvik Harbour. Several of the ships have only minor damage, and a new company has now been formed by a number of Oslo shipowners and a Narvik firm with the object of salving as many of the vessels as possible. Salvage operations will start in the spring, and ships that can be repaired will probably be taken into dry dock at Bogen, near Narvik. There are eight German, four British, four Swedish and three Norwegian vessels, totalling about 100,000 tons.

Northern Ireland Fishing Harbours.

In the Ulster House of Commons recently it was stated that the Minister of Commerce is seeking the advice of a consulting engineer on the state of fishing harbours in Northern Ireland. As a preliminary to a detailed survey the consultant is examining data supplied by the Ministry, and there will be no avoidable delay in completing a report. He will also examine the facilities at Ballycastle and Rathlin Island for the purpose of suggesting improvements capable of being carried out at a reasonable cost. The statement was made in reply to a question on the inadequate safeguards and facilities in harbours used by the fishing fleets.

More Imports for South Wales.

As a result of representations made to the Government by business interests in the area, the South Wales ports are to have a greater share of the country's import trade. Under a Government scheme to direct more tonnage to the ports, a considerable improvement is expected in imports of foodstuffs. An agreed percentage of the country's imports is to be handled. This will cover meat, dairy produce, all types of canned foods, fresh fruit, vegetables, etc., and will give the ports a larger general cargo trade than pre-war. At the same time every effort will be made to expand the present heavy trade in iron-ore, steel and other commodities. Meat and produce cargoes are expected to be directed here at the rate of one every six weeks, which will mean the more regular use of the large modern cold store at Cardiff, which was built for war purposes and has handled very little trade recently.

The Port of Cochin, South India

An Account of the Development of a Natural Harbour

By SIR ROBERT BRISTOW, C.I.E., M.I.C.E., M.I.M.E.

(Continued from page 272)

Development Plans

1930.—The harbour had now been opened and ocean-going ships were using it regularly all the year round. Its maintenance had proved feasible and inexpensive. There was no need to raise its dues and the capital charges were within the estimate. Under an Order of the Madras Government, G.O. No. 468 of 31st July, 1925, containing a "Summary of points agreed upon by the Government of India, the Madras Government and the Darbars of Travancore and Cochin for the development of Cochin Harbour," the necessary conditions had now been fulfilled for "the conversion of the harbour into a really important port." This agreement had been signed by the Chairman and Vice Chairman of the Port Conservancy Board in accordance with a Resolution No. 10 at a meeting on 13th November, 1924. The way was clear, therefore, for the next large development, and plans and estimates were prepared, not merely for the first and most obvious requirements, but for a scheme which looked forty years ahead and provided for stages of development to correspond with estimated stages of necessity and availability of funds, in an overall integrated programme. The plans and estimates were accompanied by a model and by charts of the expected growth of trade.

However, the world-slump of 1929-30 had crippled a good seller's market and there was widespread apprehension that further expenditure might increase port charges, while the provision of main wharves would reduce the private lighterage traffic between ship and shore. This, of course, is a well-known problem among Indian harbour authorities, and, from the first, the Government of Madras had provisionally reserved to private enterprise the handling by lighters of 500,000 tons of backwater traffic per annum, which was a liberal estimate for a maximum year at the time. Thus, in 1930, there developed a difficult position which lasted until 1935 and demanded repeated consultations and conferences, three in Madras and four in New Delhi and Simla.

An agreement was delayed not so much by mercantile interests as by two other great difficulties, which had now come to a head: (1) The harbour area lay within two jurisdictions, those of the Cochin State and British India. Surely, it was thought, there could not be **two** authorities administering the same port? (2) The trade had grown markedly since 1924 and the curve moved so steadily upward as to suggest even greater expansion. For various reasons this affected the financial agreement made in the "Summary of Points," mentioned above, and the Government of India found it impossible to reconcile the probable effect of the agreement with its original intention.

Let me conclude this section by adding that, in the preparation of our case for ultimate development, we were guided first and foremost by particulars of the growth of world ports given from time to time in "The Dock and Harbour Authority," which proved to be a mine of information and gave us an authoritative backing for our figures and prognostications which, though often challenged, were never disproved. Indeed, the estimated "curve of growth" which we deduced has proved, so far, remarkably accurate, in spite of the war; and we owed much to these instructive statistics for our basic ideas.

Conflicting Views

I must now go back a few years. In the autumn of 1932 a scheme of wharf development, establishing the wharfing principle, but, to meet the merchants as far as possible, reducing the first instalment of it, was jointly accepted and, at our suggestion, referred to three consultants in London, all of whom, alas, died a few years later. There were two important modifications arising from this consultation: (1) In our lay-out we had shown separate wharves for metre gauge and broad gauge traffic, the port railways being so arranged that neither gauge crossed the other. A 2-ft. gauge line, however, ran within and outside the transit sheds and warehouses for convenience in loading both "broad and narrow gauge" sheds from the same ship alongside—and vice versa, of course. For this the Committee substituted one transhipment platform at the main sidings outside the wharf premises and ran the broad gauge only direct to the wharves. (2) In our design for the wharf, we had departed from traditional types and conceived a ferro-concrete structure like a big egg-box on stilts sunk into the reclamation and reinforcing the whole wharf area—this because of its alluvial origin. For this arrangement the Committee substituted an interlocking steel pile frontage tied back to a strong anchorage. I was not convinced of the ultimate value of either of these modifications, but it was clear to me that it would embarrass the Governments still further if there were disputes on technical matters, and so, on their behalf, I accepted the amendments. As it happened, however, the Railway Company opposed the provision of a metre gauge connection to the port, and the need for the transhipment platform did not arise. The wharf, as will be seen later, proved successful, but whether due to the revised design or to a later method of strengthening it, may well be a matter of speculation. However, by 1935, all had been settled and we started on our major works.

The proposals we put forward in 1930 were estimated to cost £1,125,000, but the first instalment of them, now approved, was to cost rather less than £750,000. The wharf would take two large ships instead of four. It was to be linked by a composite rail and road bridge to the mainland on the one side and by a road bridge to Mattancheri and Cochin on the other. The road bridges were to be capable of taking 10-ton lorries. Alongside the wharves there were to be five transit sheds and warehouses, 400-ft. long, and ships' holds were to be plumbed by six level-luffing cranes. Both the wharf and the buildings were to be directly connected to road and rail traffic. Other items included a power station, the port railway and passenger stations, a water supply, roads, buildings, and a slipway for the dredging pipeline. Approval was given later to the purchase of new dredging plant, a new block of administrative buildings, and a port hotel for the accommodation of passenger traffic. On the whole, we were satisfied with these results.

Willingdon Island

Let us now examine some of the broad principles which governed the lay-out of Willingdon Island and the old island of Venduruty, to the west of it. By a series of comparisons, we ascertained that we should allow about 266 tons per annum per lineal foot of available wharf frontage for our ultimate capacity. This gave us a "target" total of 4,000,000 tons per annum. Allowing another million for traffic handled at Mattancheri and British Cochin, we arrived at an ultimate maximum for the port of 5,000,000 goods tons. This compared with roughly 8½ millions at Calcutta, 6½ millions at Bombay, 2¼ millions at Karachi and 1¼ millions at Madras. By another series of comparisons, we discovered that for 4,000,000 tons of goods per annum we should require a total of about 200 acres of marshalling yards in all, but not necessarily in one place. In addition, we knew that we should require a large area for an aerodrome and another for a naval base. These

Port of Cochin, South India—continued

we sketched out in what we thought would be the most likely places and then set out our first instalment of four large berths in the middle of the western frontage, from which to expand north and south, as trade demanded. Then we designed the rail and road systems to suit this broad conception. Concurrently, the drawing office plotted the curves of expansion for all the ports of which we could find records, and then drew a "curve of average trade expansion," the curves starting from the years in which deep-water wharves and railway connections were provided. We found that our assumption of five millions of goods tons over a period of 40 years was **below** this "average curve of expansion," and we made the proviso, too, that its realisation would depend upon the port being connected to both broad and metre gauge railway systems and to the main trunk roads.

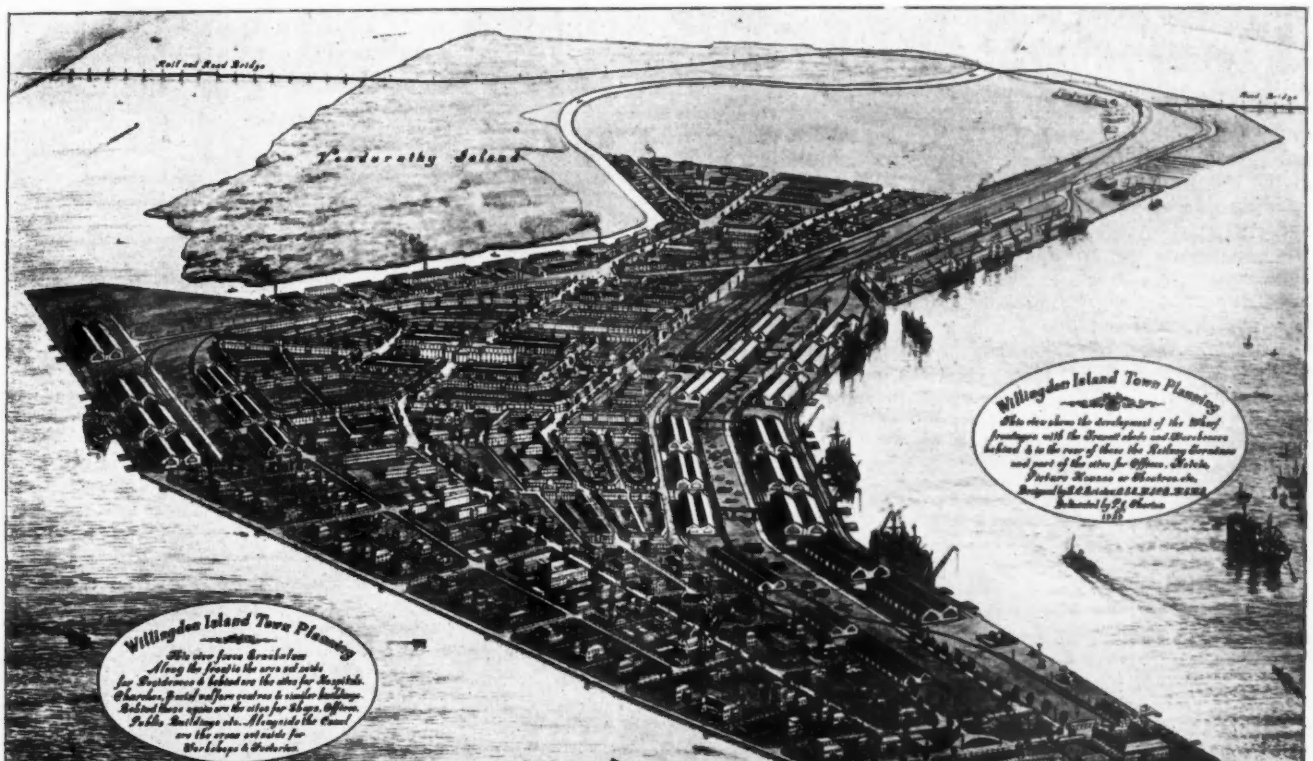
The result was received with friendly derision, polite incredulity, or non-committal agnosticism, according to the interests concerned. The criticism levelled against us was that the total was almost ridiculous, in any case; that the port could find no new traffic, except by diverting it from other long-standing ports or roadsteads; and that there was no real need for deep wharves, anyhow. To this we replied that, "if there was one place in India which lent itself to the making of a great harbour, that place was Cochin and no other; that there was a wonderful system of backwaters and interior canals; that there was a great hinterland properly belonging to the port, containing some of the richest producing areas in India; that the people were the most literate in India; that their rate of increase was also among the greatest in India; that the development of Cochin was essential politically, socially and industrially; and finally, that nobody was committed to any further development unless the state of the trade clearly demanded it." In the end this view prevailed, and, at the time of writing, the "average curve of growth" for Cochin is being steadily fulfilled, the traffic in 1945 having risen to about $1\frac{1}{2}$ millions even without the provision of the metre gauge connecting link to its principal hinterland.

Financial Considerations

We now turn to the estimates. These were recast in 1930, when the slump was still on, but by 1935-36 it became known to me privately that we must buy steel at once. Without waiting for detail drawings, therefore, we immediately obtained tenders by advertisement and by cable for all the steel, copper-steel, cast iron and cast steel that we should require, according to our own and certain type designs already in existence with the Government of India. By rapid co-operation with the Railway Board of the Government of India and with the two Departments of Indian Stores—one in London and one in New Delhi—we were able to place orders in record time and so saved some 80 to 90 thousand pounds. By bringing great pressure to bear on the Finance Minister to the Government of India, we were also able to place a contract for our new maintenance dredging plant, for by this time the Willingdon Island reclamations had been completed and henceforth the siltage in the harbour would have to be taken to sea and deposited there. We shall deal with these matters presently, but meanwhile it is instructive to note how nearly we were to incur a debt some £85,000 more than we ought, as a result of administrative difficulties and long drawn-out arguments during the years 1931-1935.

Bridge Design

We turn to the designs—and first to the bridges. There were three of them, two of about 2,000 feet span and one of 300 feet. These were known respectively as the Combined road and rail (afterwards christened the Rama Varma, after the then Maharajah of Cochin), the Canal, and the Muttancheri. While the demands of economy and practicability plainly pointed to the simple cast iron cylinder and plate girder type of construction, we



Willingdon Island.—Ultimate lay-out as first designed.

Port of Cochin, South India—continued

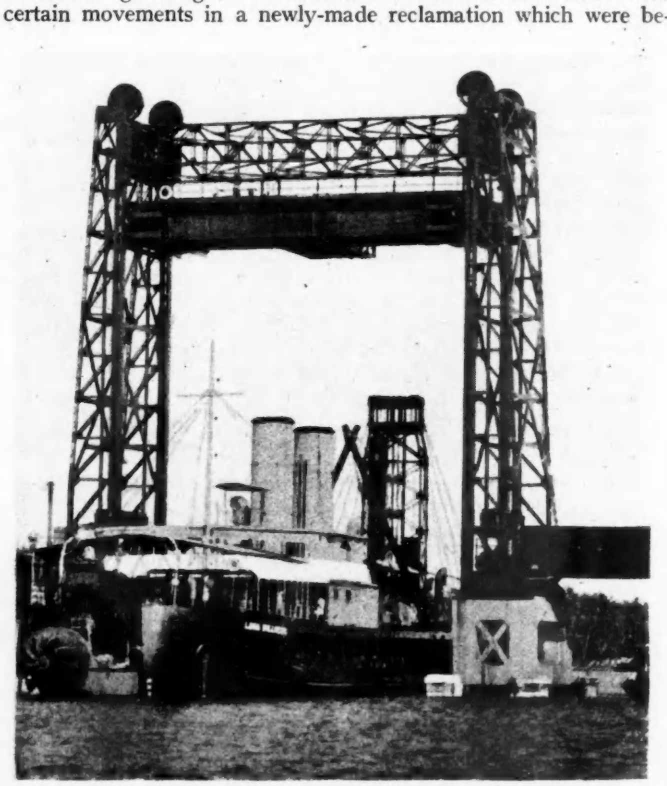
would have liked something more attractive in such a beautiful setting, and for many years were experimenting with designs for a granite superstructure of arches on metal cylinders, or for longer ferro-concrete arches of the new Waterloo Bridge type on clusters of ferro-concrete piles. In every case, however, we were beaten on the problem of foundations. There was no rock within 400 feet below low water, and the best soil our borings could find was a lateritic clay at roundly 70 feet L.W.O.S.T. The channel in its deepest part was 30 feet L.W.O.S.T., and at springs the floods ran at 2 knots. On the freshets plus ebb springs, the outgoing current might reach 3 to 3½ knots; actually, in 1924, 5 knots. Our designers therefore set to work on the difficult problem of finding the economic spans of girders for a cylinder and plate girder bridge to take the "heavy mineral loading" of the Railway Board's specifications. The whole problem lay in determining at what point below bed level the cylinders could be regarded as "fixed." One expert draughtsman deduced an economic span of 60 feet and another of 80 feet, but meanwhile, looking at the matter as a harbour engineer, I had come to the conclusion there would be much erosion at bed level if the piers were less than 100 feet apart. With ordinary mild steel girders, this meant a larger cylinder and bottom screw than we could comfortably manipulate, but in discussion with the Senior Inspector of Railways it was found that we might reasonably assume a smaller loading than "heavy mineral," and that high tensile steel girders would probably give us the 100 foot span I wanted, without exceeding our bottom loading.

By great good fortune the designing branch of the Railway Board had just completed a type design of a 100 foot span, 45-ton tensile, steel railway girder. By increasing our cylinders from 3 feet to 3½ feet in diameter, and designing the screws in three sizes to suit varying loads, we were able to adopt this girder forthwith and so ironed out three awkward difficulties in the one process: the immediate ordering of the materials, the possible objections of the Railway Company concerned, and the probable excessive erosion round the piers, which I had feared. As it turned out, this erosion occurred even with our 100 foot openings, but it was within manageable limits, and, as the scouring developed, we filled up the holes with concrete and rubble and thereby made the fixing at bed level stronger than it was before. There were six cylinders in each group, the middle pair taking half the rail load and half the road load—the railway and roadway lying side by side. The greatest scouring, of course, was in the deeper part of the channel. It was negligible as the cross-section shallowed towards the banks.

I wish it were possible in the space available to describe the day to day operations of our new bridge-building division; how, with a background of wide experience, with an excellent staff, and with unfailing ingenuity they overcame every emergency; how they were helped by other sections of our harbour staff; and how, in the end, the bridges withstood the most severe tests by the Railway Company. But this would require not a few paragraphs but a long paper illustrated by many photos and drawings. But if we are to concentrate on the design, we may mention that a large saving was effected in the combined road and rail bridge by the introduction of one central "through" span in a long bridge of "deck" spans, the rails running respectively on the lower flanges of the first and on the upper flanges of the second. In this way, we confined navigation to the central span and saved 9 feet of height on the cylinders supporting the deck spans, besides a great amount of filling in the approaches. The head-room under the "through" span was about 23 feet, and the bottoms of the "deck" spans were well above flood levels. It has to be admitted that architecturally the result could hardly be described as impressive; "utilitarian" or "austere" would be better words. By ingenious (and useless) superstructure where the through span joined the deck spans, we could have presented, from a distance, a more imposing elevation, but we decided to leave this to posterity.

The Wharves

Here again, the long delay had given much time for reflection. We had to combine safety with economy of capital and maintenance costs, and one by one we eliminated every known type of wall. At last we thought of our "egg-box on stilts," sunk well into the uncertain soil of the reclamation. Every harbour engineer knows that a soft slope under a piled jetty stands at a steeper angle than the contiguous banks. This gave us our clue, and I was surprised at the reception given to it by our consulting committee, for, unlike our prototype the jetty, we had tied our "egg-box" back to a piled anchorage as well, and, like the jetty, our "egg-box" was several tiers in width. The longitudinal and cross walings were 4 feet deep, constructed in ferro-concrete and buried in the ground, but above high water neap tides. The Committee thought that, whatever happened, the forward strain would be the same and would need the same anchorage, and that the "egg-box" was then superfluous if the front piling were made strong enough. I advocated the notion that there were certain movements in a newly-made reclamation which were be-



Mattancherry Bridge.—Lift Span raised and Dredger passing through.

yond calculation and that the "egg-box," with its stilts (or piles) at every intersection, provided a factor of safety not otherwise obtainable, especially with a frontal depth of 30 feet at L.W.O.S.T. Our model, moreover, gave us an extraordinary result, the formation greatly decreasing the "wedge" pressure acting on the front piles, and I am sure that the structure would have been wholly stable even though a model can never give field conditions.

However, we adopted the Committee's alternative of steel sheet piling tied back to an anchor wall, a simple system if the angle of repose and the toe reactions can be everywhere determined. But as we proceeded to carry this into effect, my instinctive feeling of danger hardened into certainty, and I decided to leave a supporting bank outside the piling at a slope of about 1½ to 1, with sufficient depth at low water to float steel fender pontoons. These kept the ships about 40 feet away from the wharf edge, and by increasing the radius of our cranes to 85 feet and reducing the load of some of them, we achieved absolute safety plus sufficient loading efficiency, for 90 per cent. of our loads were less than 1½ tons. Moreover the pontoons, about 50 feet by 37½ feet, plus fenders, gave invaluable service elsewhere, first in the bridge-building by floating the built-up girder spans into position and depositing them in place as the tide fell, second as temporary 100-ton water floats for supplying ships before the wharf supply

Port of Cochin, South India—continued

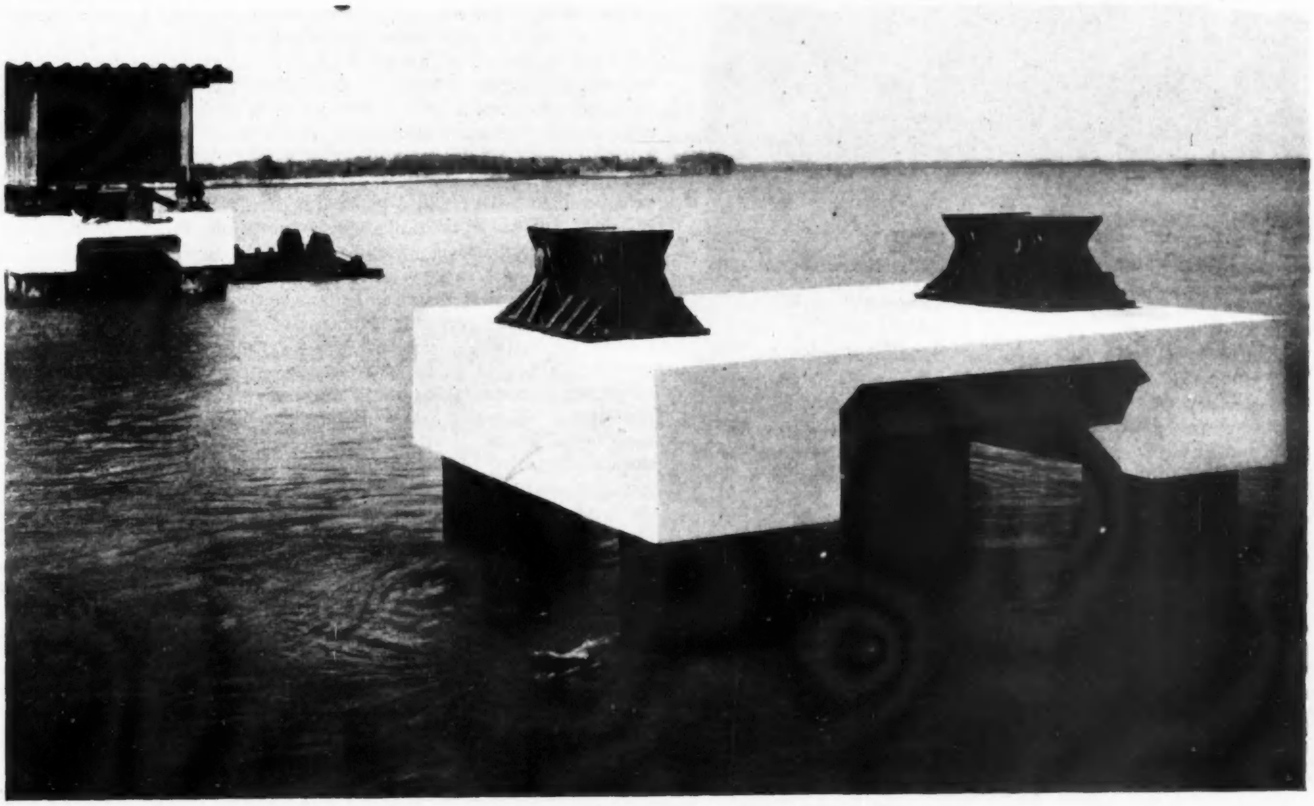
became available, and third for any emergent purpose, of which there were several. Finally, building better than we knew, they enabled us to float lighters **inside** the ships lying against them at the wharves, so that the wharf cranes could unload **shore** cargo and the ships' derricks could unload **backwater** cargo on the port and starboard sides of the vessel, simultaneously. They also gave the ships' ropes a better lead to the shore bollards and, I think, kept the rats away, because of the greater distance between the shore and ship and the absence of **shadow.** Altogether, we were well satisfied and, of course, the Committee's proposal gave us a cheaper job—for first cost. What the " life " of the copper steel piling will be remains to be seen. We used a strong Krupp section.

Again, I wish it were possible to describe in detail the construction of this wharf. Our pile-driving, in particular, yielded wonderful results, the outcome of the closest attention to detail and the precognition of probable difficulties. Never was one pile driven a quarter of an inch out of position from side to side or from back to front, and those who know anything about sheet-piling to a depth of 60 feet in a variegated soil know what this means. The total cost of this deep wharf amounted only to 600 rupees (£45) per lineal foot, and, so far as I am aware, it has proved completely satisfactory. The cranes were made by Messrs. Cowan Sheldon & Co. and answered their purpose admirably.

Buildings

The erection of substantial buildings on Willingdon Island was one of our main problems. There were two uncertain factors: first, the reclamation itself was new; and second, we did not know to what extent the original soil below the reclamation would sink by the weight of the reclamation plus the weight of buildings. The first substantial building erected was my own office, with quarters over it, and here we started with a piled foundation and an 18 inch concrete raft armoured with railway metals, the timber piles penetrating some 20 feet below ground level. I judged from my previous experience elsewhere that this would be satisfactory, but we took the precaution of keeping the ground floor level some 15 or 18 inches above what would normally suffice. In a year or so, the whole raft and piles and surrounding earth sunk unevenly—about 2½ inches at one angle and 5 inches at its diagonal. A cement jointed drainage pipe from the ground floor to a brick manhole outside was **not sheared** in spite of this settlement. After this, we took levels all round and in a few years the settlement ceased. In other residences, built soon after, we noticed that a pair of semi-detached houses, forming in shape a dumb-bell, subsided more in the middle than at the ends, the distribution of weight being heavier in that section. From these two experiences, we turned to the plan of a wide foundation under the walls plus piling, with a calculated load on each based on a series of test-piling.

However, we still had sinkage, though less and not enough anywhere to show cracks. The whole structure settled a little bodily, piles as well. As to these piles, the cheapest and quickest results were obtained by driving down unsquared logs of teak or ***maradu***. Where, by reason of some irregularity, this left an annular ring of space round the pile, we filled the hollow part with a grout of cement and sand. It is well-known, of course, that a timber pile completely buried in ground will last for generations, provided that the white ant cannot attack it. At that time there were no white ants on Willingdon Island, but they came later with crates of crockery and carpets when the port hotel was built in 1935 and Messrs. Spencers, of Madras, took over the furnishing and management. This came as a shock to us and we took active steps to exterminate the " queens " as rapidly as possible, and always thereafter kept a watchful eye on the foundation piling. The first " queen " we ran to earth had actually found a home in the laterite basement wall of the hotel. It has to be remembered that the purpose of our piling was primarily that of taking part of the load for the first 10 or 15 years of settlement. The concrete foundations were made wide enough to take the whole load when the process of consolidation was over. I think this policy was the correct one, and I would



Mattancherry Bridge.—R.C. Beam and Slab over Cylinders.

Port of Cochin, South India—continued

not alter it if I had to do the same work again. Piling and driving cost us about 1½ to 2 rupees per lineal foot of pile in *maradu*.

For building, we used brickwork for piers and laterite blocks for walls, the latter 18 inches thick and rendered both sides. It was an excellent material for tropical use, cheap and cool, though heavy. Doors, floors and joists and window frames were usually of teak, and roof timbers of *maradu* or some other jungle wood. Roofs were covered with local tiles of excellent quality, a plain tile below and a locking tile above, breaking joint and giving a good watertight roof. In this way we could, if we wished, dispense with a ceiling, thereby greatly increasing the air content of a room, and excluding rats, toddy cats and other vermin from the roof spaces. We trained a splendid body of builders. Our hotel was built in 4½ months and our Administration Block in 6 months, at a cost of roundly 4 annas per cubic foot. The big warehouses and transit sheds, of course, cost less. For work of equal quality in England to-day, the cost would be from **eight to ten times as much,** or even more. For the roofs of the transit sheds and warehouses, we used steel trusses and purlins, covered first with "Big Six" (or equivalent) asbestos sheeting and then, over that on teak battens, a layer of tiles. This gave us a watertight and cool roof. It is a strange comment on the teak situation that, although we had an excellent teak in Malabar, it was cheaper, for flooring, to import it from Burmah already "thicknessed," tongued and grooved. This cost roundly 5 rupees (or 7s. 6d.) per cubic foot delivered.

Combined Rail and Road Bridge. Interior view of Bracing. (Road Bridge side)

We started these major works in 1936 and within two years the whole of the screwing for the cylinder foundations of the bridges was completed. In 1939, by the time war was declared, the works were practically completed according to plan and estimate, and without a hitch from first to last. Immediately we set to work on war requirements. For many years previously we had bombarded successive Directors of the Royal Indian Marine and Naval Commanders-in-Chiefs with the idea of developing the harbour for war purposes—not that they needed much bombarding, for one look at it from their experienced eyes was enough. One and all, from Admiral Tothill in 1920 to Admiral Fitzherbert in 1938, they were our allies, heart and soul. Immediately on my return from leave in 1938, I wrote a secret memorandum on the subject of defence and followed this up with urgent proposals for an aerodrome. Admiral Fitzherbert at once, and on his own account, took up the question of erecting a Naval Depôt at Cochin. The approval to the construction of the aerodrome came after somewhat unusual pressure, as I will relate.

The Aerodrome

For trial purposes we had reserved a large area of Willingdon Island and earmarked it as the best flying site in the district. When burning the long grass off this, we discovered that the silt which had been pumped into the area burnt like a brick! I had often had the idea that the port might get a good revenue from this large area, and had been advised that it would produce two crops of sugar cane annually. Its potentialities as a brickfield suddenly occurred to me, and my staff promptly made a couple of perfectly good bricks from the material, plus a little more sand. Armed with these bricks, I proceeded to New Delhi and suggested that if the area was not required for an aerodrome forthwith, we should turn it into a brickfield, as we could not keep the ground idle indefinitely. Fortunately for us, the then Director of Civil Aviation had no doubt in his mind as to the necessity for an aerodrome in this spot, and after a short time we started the work. To get a solid substratum, we first pumped into a bunded area a great mass of yellow sand (the "Lord Willingdon" again coming to our rescue), and then moved this by side-tip trucks to the site nearby and levelled it dry in a blanket of 2 feet thickness. On this we laid our granite rubble and macadam (about 1½ feet in all) and rolled it hard. Later, certain of the runways were coated with an impervious surface. In due course, the full tale of this aerodrome will be worth telling. I left in the spring of 1941 and it was then well in hand. My successor completed it and extended it.

Similarly, the site we had set aside for the Naval Depôt on the adjoining Island of Venduruty was eventually taken over and developed as we had foreseen and planned. Not only so, but the Royal Navy took up a further area south of the above and used it for their own purposes until the atom bomb relieved them from their immediate occasions.

Port Services

Before closing this section, I must say something of four important services: water, power, railways and drainage. We tried hard to get down to a pure water supply on Willingdon Island. The official "dowser" came and found a site which promised well and at some 200 feet we struck fresh water. Alas, after a week or two it turned brackish and the output was not plentiful. In due time, therefore, by arrangement with the Cochin Government, we laid a pipe over the railway bridge and put up a 400 ton tank in the wharf area. This gave us and the ships an excellent supply. For power, we purchased three sets of about 400, 150 and 150 k.w.'s from a town which had been converted to a grid system. This was enough at the time, although we always knew that we might have to take a grid supply later on. Even then, we thought, in view of possible troubles ahead, it might be as well to have a stand-by of our own. For drainage, we relied on a system of septic tanks discharging into the backwaters, and also on local disposal of night soil. Up to the time I left, this had been found satisfactory, but our final plans envisaged an ejector system and disposal by the activated sludge principle for farming purposes on the adjacent island of Venduruty. In the matter of railways, we made an arrangement with the South Indian Railway Co. to loan expert supervisors during the construction period and then to work the port railway for the first few years. But not a few disputes arose over traffic rates to the new terminal, and we had to draw pointed attention to what appeared to us to be distinctly anomalous proceedings, which brought acute differences of opinion with the Railway Authorities. As a pleasant contrast, the Steamship Companies began to bring their passenger vessels regularly to Cochin in 1935. The P. & O. *Comorin* came first, but the Bibby Line ran a regular service just after. This was an exceedingly well-run business adventure and the local agents deserved, and received, great praise for the arrangements made. We, on our side, had done our best; we provided a hotel, a swimming pool, a post office, a bank, a railway siding, a Customs house and a shore berth all within a hundred yards of each other, with the Port Administrative offices next door. The best terminal I know. Finally, our estimate of 1920, which included for the same capital works, or their reasonable equivalent, amounted to 203½ lakhs of rupees. The audited accounts showed a saving equal to £94,000, over the period 1920-1940, and practically the whole of the work had been carried out departmentally.

Permanent Scheme for British Dock Labour

Issue in Draft Form

It is announced that a new Board, to be called the National Dock Labour Board, with functions as set out below, is proposed by the Minister of Labour, to be created in place of the existing port executives, to deal with all matters in connection with the control of labour at British ports.

The functions are:

(a) Ensuring the full and proper utilisation of dock labour;

(b) Regulating the recruitment and entry into and the discharge from the scheme of dock workers, and their allocation to employers;

(c) Determining the size from time to time of the live registers or records and the principles to be followed in the event of any increase or reduction having to be made in the numbers of any such registers;

(d) Keeping, adjusting and maintaining the employers' registers, entering or re-entering therein the name of any person by whom dock workers are or are to be employed and where occasion requires it, removing from the registers the name of any employer, either at his own request or in accordance with the provisions of the scheme;

(e) Keeping, adjusting and maintaining the live registers or records and any registers or records of dock workers who are temporarily not available for dock work and whose absence has been approved by the local board;

(f) The grouping of all registered dock workers into such groups as may be determined by the National Board after consultation with the National Joint Council, and thereafter reviewing the grouping of any registered dock worker on the application of the local board or of the dock worker or any of the bodies of persons appearing to the National Board to be representative of such workers or employers;

(g) Making satisfactory provision for the training and welfare of dock workers, in so far as such provision does not exist apart from the scheme;

(h) Levying and recovering from registered employers contributions in respect of the cost of operating the scheme;

(i) Borrowing or raising money and issuing debentures or other securities and, for the purpose of securing any debt or obligation, mortgaging or charging all or any part of the property of the National Board.

Ports Involved

The ports to which the scheme relates are the following:

AYRSHIRE PORTS: Ardrossan, Ayr, Irvine, Troon.
BARROW-IN-FURNESS.
BRISTOL AND SEVERN PORTS: Bristol, Sharpness, Gloucester.
CORNWALL PORTS: Charlestown, Falmouth, Fowey, Hayle, Mousehole, Newlyn, Par, Penryn, Penzance, Porthleven, Portreath, St. Ives, Truro.
CUMBERLAND PORTS: Maryport, Silloth, Whitehaven, Workington.
EAST ANGLIAN PORTS: Boston, Great Yarmouth, King's Lynn, Lowestoft, Sutton Bridge, Wisbech.
EAST COAST OF SCOTLAND PORTS: Aberdeen, Bo'ness, Burntisland, Dundee and Tayport, Grangemouth, Kirkcaldy, Leith and Granton, Methil.
PORT OF FLEETWOOD.
PORT OF GLASGOW.
PORT OF GREENOCK.
GRIMSBY and IMMINGHAM.
HULL and GOOLE.
PORT OF IPSWICH.
The statutory area of the PORT OF LONDON, together with the cold stores and premises in the vicinity of the port which immediately before the coming into operation of this scheme were deemed to be included in the Port of London for the purposes of the Dock Labour Scheme for the said port made pursuant to and for the purposes of the Essential Work (Dock Labour) Orders, 1943 to 1945.
The statutory area of: The Medway Conservancy, Queenborough Harbour Authority, Milton Creek Conservancy, Faversham Navigation Commission, Whitstable.
THE MERSEYSIDE PORTS.
The statutory area of: Bromborough, Ellesmere Port, Garston, Liverpool, Manchester, Partington, Preston, Runcorn and Weston Point, Widnes.
MIDDLESBROUGH and THE HARTLEPOOLS.
PORT OF PLYMOUTH.
The statutory areas of: Southampton, Poole and Hamworthy, Weymouth.
SOUTH WALES PORTS: Barry, Cardiff and Penarth, Llanelly, Newport, Port Talbot, Swansea.
TYNE and WEAR PORTS: Gateshead, North Shields, South Shields, Sunderland, Blyth, Seaham Harbour.

The new National Board may delegate to the Local Boards the responsibility for keeping, adjusting and maintaining the registers of labour. Only registered labour is to be engaged on dock work and by a registered employer.

The scheme is to take effect as from July 1st next.

River Wear Commissioners

Report at Annual General Meeting

At the Annual Meeting of the River Wear Commissioners, held at Sunderland on the 20th ult., the Chairman gave the following brief review of the affairs of the undertaking.

Coal shipment in 1946 were 2,304,886 tons against 2,143,359 tons in 1945, and 4,449,719 tons in 1938. The Commissioners touched bottom in this trade in 1943 with 2,090,035 tons, so that over the last four years they have slowly recovered about a quarter of a million tons towards making up the two million tons of business lost. The movement, though very gradual, was in the right direction; and the other coal-shipping ports are in the same plight—some of them worse, notably in South Wales. But the coal trade has always been the life blood of their undertaking, and, whilst they were seizing every opportunity to develop other trades, they will always have a hard struggle to meet their annual expenditure until the coal trade picks up again.

Imports in 1946 amounted to 219,645 tons against 78,989 tons in 1945—a very welcome recovery in their normal trades. The 1938 figure was 325,531 tons. Two of the brightest spots in the year's work were, first, the recovery of the iron ore business—they received 82,942 tons in the year, the highest import for 10 years—and, second, the attraction to Sunderland of a new steamship line, the British India Company, bringing regular cargoes of hemp and other goods from East Africa. The year also saw the recommencement of the Swedish-Lloyd Service from Gothenburg, the first revival of trade with Finland, some recovery in pitwood imports, and other encouraging signs of post-war revival. Very great efforts were being made with a view to recovering pre-war traffic and seeking new business.

Exports in 1946 amounted to 76,613 tons, which compares with 74,496 tons in 1938. In this small section of their trade, they were therefore back to pre-war level, but they will continue to strive, by every means in their power, to improve on the pre-war figures. The total shows a great drop from the abnormal war-time exports of war material, which amounted to three-quarters of a million tons in all, of which over a quarter of a million was shipped in 1945.

It was that tremendous and valuable export business which got them through the war, without any financial loss, in spite of losing half their coal trade. In 1946, they had their first year's experience of diminished coal trade without any abnormal export trade to cover it up. The result was that they finished the year £31,376 on the wrong side. It was a year of peace, but it had many of the marks of the war upon it. Taking the eight years 1939 to 1946 together, however, the net working result over the whole period revealed a surplus of about £23,000.

As regards the Corporation Quay, after its prodigious contribution during the war years, the process of picking up the threads of peace-time trading was proceeding satisfactorily. It appeared likely that for the 12 months ending 31st March, apart from the war years, the quantity of general goods handled would be the largest since the quay was opened in 1934. The quay remains the most attractive general cargo berth in the port and it is one of the chief factors in attracting new trade. But, in effect, it is only a one-ship quay at present and the Corporation are therefore pressing on with their Bill, now in Parliament, to extend the quay

River Wear Commissioners—continued

to provide another first-class berth. This, combined with the proposed river-side Cold Store, will give them further opportunities to develop the trade of the port.

They were going straight ahead with their Ten-scheme Programme of Port Improvement. All necessary sanctions have been obtained and their engineer is putting the work in hand, scheme by scheme. As the present year runs its course, they will watch with great interest the development of these important works.

In addition to the programme already approved, they were continuing their consideration of two further projects—the improvement of the entrance from the river to the docks, and the construction of new inner piers at the harbour entrance.

According to the information available to them, 50 new vessels were launched in the port during 1946, totalling about 106,450 net register tons, and there is work on the books for several years ahead.

Last year, the Chairman referred to probable impending proposals relating to a re-organisation of port administration in this country, and since then the Commissioners had seen and studied the Government's Transport Bill. Under the Bill, public trust ports—such as Sunderland—are not scheduled for nationalisation, but they will be kept under continuous review and they may be made the subject of regionalisation or combination schemes. Addressing the Dock and Harbour Authorities' Association last month, Mr. G. R. Strauss said that there seemed to be a fear that docks will be controlled by a remote and central authority, with consequent removal of local autonomy; and he went on to say that the Government will see that that does not happen. Whatever the future course of matters may be, their duty as River Wear Commissioners was very clear. They must do their utmost to ensure that the achievements and potentialities of the Port of Sunderland are given their proper place in the new scheme of things, and they must secure for the port the opportunity of full development in the future, so that it may continue in its vital task of bringing work and trade to Sunderland by serving the community at large.

Ice Blockade of Canadian Ports

(concluded from page 304)

The design of outlet rivers that will flow free of ice throughout the winter:

1. From Lake Superior to Lake Huron—Such a river might be either with or without locks.
2. From Lake Michigan to Lake Huron. The winter closing of the Straits of Mackinac and the opening of a suitable channel via Little Traverse Bay and Cheboyagan is a possibility.
3. From Lake Huron at some point north of Sarnia to a point on the Welland Canal below the guard lock. Lake Erie from the standpoint of winter navigation calls for thorough study. The lake is relatively very shallow and therefore liable to freeze over early, but, in general, climatic conditions in its immediate area are much milder than they are around the larger lakes. It is not a case for off-hand conclusions. An isolated channel along the north shore of the lake and carrying most of the flow of the St. Clair River offers one solution to this problem. Such a channel could empty into the Welland Canal below the guard lock and possibly the level of main reach of the Welland Canal could be lowered.
4. From Lake Ontario to a point near Longueuil including the possible extension of the Lake St. Louis level to Longueuil and the construction of a power development of the first order at or near Longueuil.
5. From Montreal to tidewater following the plans suggested long ago by Mr. T. C. Keefer.
6. The extension of the Lake Champlain level from a point on the St. Lawrence River near Laprairie to a point on the Hudson River near Albany. The two main problems in this area are the providing of a sufficient water flow to keep the connecting channels free from ice during the winter months and the control of the surface ice on Lake Champlain.

It may be noted that river channels designed on a principle of heat conservancy will probably always be deeper than would be required to float the largest of present-day vessels.

Considering the ultimate possibilities for improvement of the St. Lawrence and Great Lakes waterway and comparing them with present-day plans, the writer is reminded of the comment made by Mr. T. C. Keefer some seventy odd years ago: "Canada always builds her canals to designs that are obsolete before construction has commenced."

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MARINE SALVAGE EQUIPMENT.

The Director of Navy Contracts will shortly have for disposal a large quantity of surplus marine salvage gear in serviceable condition.

Salvage Companies and Authorities interested are invited to register their names forthwith with **The Director of Navy Contracts, Branch 8D (S), Foxhill Hutments, Bath, Somerset.** It would be convenient if outline requirements could be indicated at the same time, but this is not essential. Applicants will not, of course, be under any obligation to purchase as a result of such registration.

Registration will, however, ensure that those interested will receive invitations to tender for purchase of the gear when available, and is therefore important.

GREENOCK HARBOUR TRUST.

35 Ton Electric Travelling Portal Crane for Sale.

The Trustees of the Port and Harbours of Greenock have for sale, as it stands on the site on the Coaling Jetty, James Watt Dock, Greenock, a modern electric Travelling Portal Crane, as built and delivered by Messrs. George Russell & Co., Ltd., of Motherwell, in 1944. The Crane is of the fixed jib Portal Carriage Type, designed to lift 35 Tons at a radius of 60 feet at a speed of 57 feet per minute to a height of 85 feet measured from rail level to jib-head pulley. The Crane tracks are at 40 feet centres spanning three railway lines for coaling operations, and a through type cradle with automatic locking mechanism is provided.

The Prime Mover is a 230 H.P. auto-synchronous motor, with Ward Leonard Generator and Control for 180 H.P. main hoist motor and 90 H.P. tipping motor. Slewing is by a 60 H.P. S.R. motor, giving a speed of 400 feet per minute at jib-head; travelling on 16 double R.S. tyred wheels is by four 12½ H.P. S.R. motors at a speed of 72 feet per minute. The crane is wired for a 440 volts, 3 phase, 50 cycle supply; "Igranic" D.C. type "M" Brakes on hoisting and tipping motions; limits on all motions except slewing; controls fully interlocked; lighting and heating throughout; instruments for indicating incoming Volts and Amps, Amps Ward Leonard Loop, Exciter Volts D.C., Exciter Amps A.C., and Power Factor Meter.

The structural and mechanical arrangements are by Messrs. George Russell & Co., Ltd.; motors by Crompton Parkinson; and controls by Igranic and Ellison. The crane is in perfect condition throughout and can be examined by representatives of prospective buyers by arrangement with the subscriber.

Offers, marked "Tender for 35 Tons Electric Travelling Portal Crane," should be lodged with the Undersigned not later than noon on Wednesday, the 21st May, 1947. The Trustees do not bind themselves to accept the highest or any tender.

DONALD SMITH,
General Manager and Engineer.

Harbour Offices,
Greenock.